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STEAM-ELECTRIC plant of Pacific Gas and Electric Company at Pittsburg—660,000 kw—is largest such plant west of the Mississippi. It is part of the itinerary for the Summer-Pacific Meeting to be held in San Francisco, Calif. Item on page 556.

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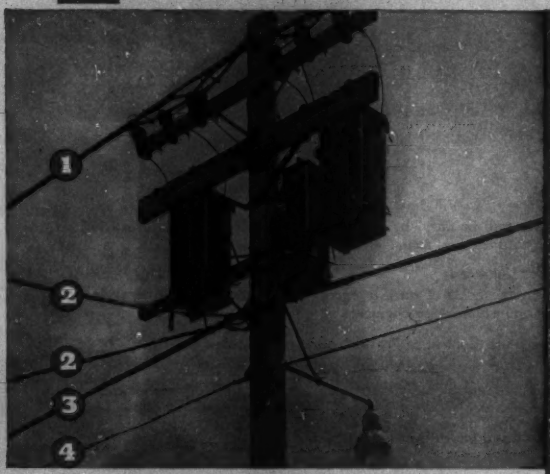

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3229

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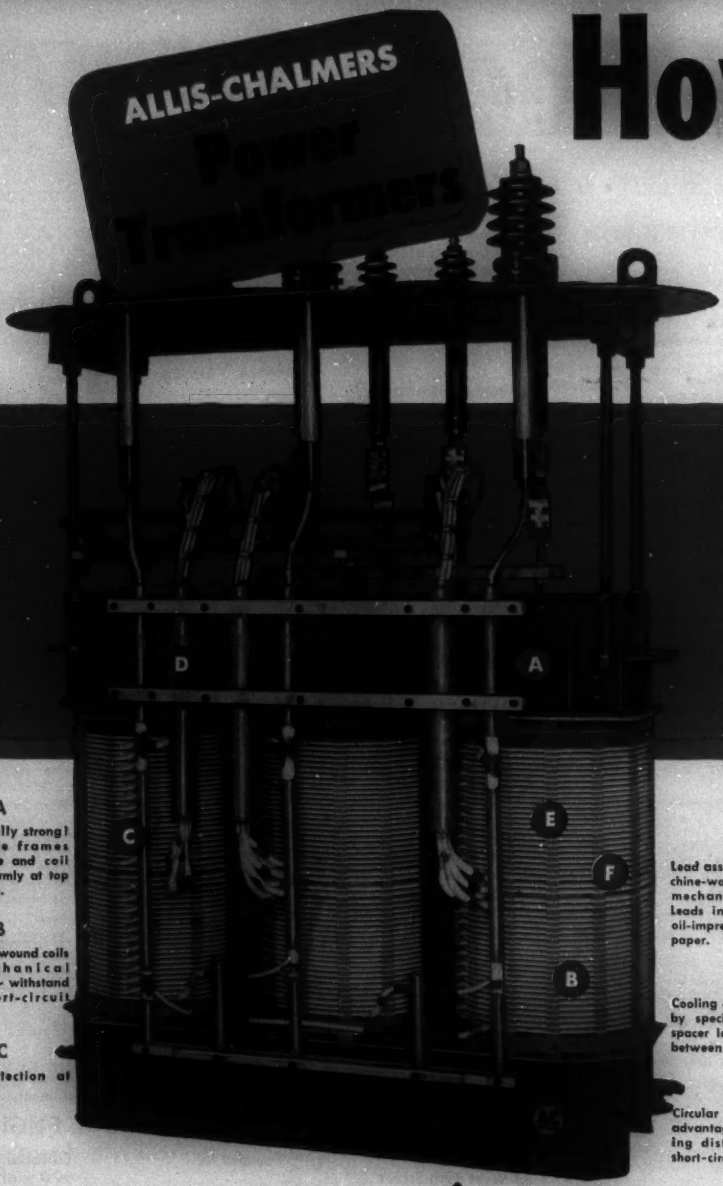

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Electrical Engineering As It Will Be

M. D. HOOVEN
PRESIDENT AIEE

To solve the greater problems to be faced by the electrical engineer of the future, he must learn to work with a team of technicians, some of whom will undoubtedly be women. Engineers will also be the intellectual community leaders who will be called upon to turn out more ideas.

ELECTRICAL ENGINEERING HAS CHANGED tremendously since the end of World War II. As in other branches of the engineering profession, progress beyond the ability of individual grasp has been made. Developments on all fronts, from the common telephone instrument with which we now dial our neighbors to the electric meter on which we pay our bills, have been comprehensive. Thinking machines are replacing the slide rule. Electronic controls are running our great industrial establishments. With the present complexity of the art itself, is it possible to forecast what the future practitioner of engineering will be like?

FUTURE TRENDS

THERE ARE already certain trends established which may give the semblance of a picture of the electrical engineer of the future. In the educational field, reforms are in process. More basic science courses, more of the humanities, and perhaps less of the specific engineering courses are being provided. Further than that, it is very probable that the type of science instruction offered in the secondary schools will change in that a bright young person will adopt the scientific attitude much earlier in life than has been the case in the past.

Obviously, then, the practitioner of the future will have more fundamental background, more culture, if you please, than the present-day engineer. Unfortunately perhaps, there will be in the profession a lesser number of the manually dexterous group, inasmuch as time for education takes time from practical engineering. The dirty-handed engineer of the past, such as perhaps many of the present generation represent, will be replaced by a more intellectual type. It is difficult to say whether this will be for the good of the profession or not; the fact remains that this is the present tendency. However, the general type of individual in the profession will be much the same, although the engineer may, by the way, be a woman, in that fifty years from now, the pressure of community requirements for engineers will be such that womanly intuition will undoubtedly be added to the graces of the profession. Ingenuity and creativity will remain much the same, with an educational effort, of course, being made to develop these common traits of all engineers, but the inherent qualities must be there to start with.

TEAMS OF TECHNICIANS

THE DEMAND for great solutions to great problems will make more scarce the lone wolf in the profession. In order to meet the requirements of the future, it is very likely that engineers will work in teams. It is equally probable that the teams may consist of pure professionals assisted by those who are technically inclined but who perhaps have not the desire to become imbued with the mathematical and scientific approach. In engineering teams of this sort, it will be expected, there will be a great number of womenfolk. No longer will it be the sole aim of an attractive young girl to spend a few years as the boss' secretary and then to retire, as she should, to the chore of raising a family. It is equally possible now that the attractions of science and computation will draw into the technical field many girls who will

Essentially full text of an address presented at the Great Lakes District Meeting, Ft. Wayne, Ind., April 16–18, 1956.

M. D. Hooven is electrical engineer, Public Service Electric and Gas Company, Newark, N. J.

spend their premarital life in the service of engineering; following, perhaps, the intellectual leadership of an engineer who directs the team approach.

Some fears have been expressed that the group approach to the solution of engineering problems may tend to destroy the present well-recognized value of the individual mind. These probably are baseless fears in that, because of the nature of the art and because engineering is peculiarly an intellectual process, the contribution and recognition of the individual can never be replaced.

COMMUNITY LEADERSHIP

THE ELECTRICAL ENGINEERS who replace the present generation will find very little time to devote to general services to the community. At the same time, the community will require more and more of the kind of intellectual leadership provided by the profession. Numerically, the professional group will consist largely of engineers because the growth in numbers of professional persons has been, and will continue to be, on the technological side. Professional and community requirements will leave little time for golf or bridge. Engineers of the present already are undergoing this experience. It is not beyond the realms of possibility that the engineer of the future will invent for his well-being an electronic exercising device which will give his muscles the required exercise while he sleeps. Recognition and recompense from his community will undoubtedly be higher than they are at present, not only on the basis of acknowledgment of an excellent contribution, but also on the basis of making entrance into the profession attractive. The continuity of the present complex civilization depends upon recruiting the optimum number of bright young minds into technological fields. Dr. Flemming of the Office of Defense Mobilization has suggested that a system of national awards be made to persons ranging from high school and college students through the teachers and professors to the scientists and engineers and to the engineering executives. These awards can be imagined as being neither monetary rewards nor empty titles. The important thing is that they constitute sound recognition. Also, as a part of the recognition problem, the engineer of the future will probably have nicer rugs on the office floor, nicer pictures on the walls, not that he cares, for as it has often been said, "Give an engineer an interesting problem and a loaf of bread and he becomes a happy individual," but because there is danger, under the present system, of siphoning off too many creative minds from research, development, and design into engineering management. Already in some industries a plan of parallel progression is being tried, where the luxuries and emoluments of office are disbursed with equality to those engineers who progress in design and research as well as to those who progress in management.

INDIVIDUAL AND GROUP INCENTIVES

THERE WILL BE MORE individual incentive. Inasmuch as the progress of the art depends on individual ingenuity and creativity, more ways will be found to reward the individual. Group rewards, known in the parlance of the day as fringe benefits, will tend to disappear, particularly those which in any way inhibit freedom of judgment of the engineer. Rewards based on seniority, job specifications, even pensions may be looked upon askance.

Engineering will come to be recognized as one profession. Perhaps major variations in disciplines will continue to be recognized; with a greater emphasis on depth of education, however, specific divisions of the engineering arts would tend to disappear. The Institute of Radio Engineers and AIEE will no longer represent a cleavage in electrical engineering. Even at present, the mechanicals and electricals operate so much alike that the differences are becoming indistinguishable. Pressure from the bottom up will bring unity of the profession. Each local area will have groups of engineers meeting on their specialty, whether it be insulated conductors or printed circuits, all, however, a part of the whole.

To sum up, tomorrow's electrical engineer will be much like today's in his ingeniousness. He will be more intellectual, less restricted in his thinking. He will be well rewarded, continuing to be goaded and enticed to turn out more ideas. He will have a high degree of community consciousness coupled with a kind of social independence. He will belong to a unified profession in which the field of electrical engineering will be capably covered by AIEE.

Aluminum Today

Want a tube of toothpaste? A package of margarine? A new skyscraper? A streamlined train? They cannot be found today without also finding aluminum. Not only is aluminum the most plentiful nonferrous metal in the world—making up one eighth of the earth's crust—but also, in less than 70 years, it has become the most important. Though still in its early stages of growth, consumption already exceeds the combined volume of copper, lead, and zinc; the older nonferrous metals whose use goes back hundreds of years.

Nearly 5,000 uses are counted for aluminum and the list grows daily.

The rapid rate at which the aluminum has grown was the result of technological developments which lowered costs from $8 per pound in 1886 to less than 25 cents today. This has helped swell volume from 17½ tons in 1886 to more than 1.5 million tons today. But price alone did not send aluminum zooming out of the pots and pans stage to fields unlimited.

Because of its versatile properties of lightness, electrical and thermal conductivity, resistance to corrosion, and aesthetic appeal, aluminum seemed to hold the answers to various industrial problems. Even with its sudden emergence upon the scene at competitive prices the reluctance of manufacturers wedded to traditional older metals to experiment with something new was encountered.

Where is the aluminum going? Today three markets—building, transportation, and electrical—account for more than half of world production, and their volume demands promise to increase tremendously.

Engineering Futures Unlimited

T. G. LeCLAIR
FELLOW AIEE

Future opportunities for engineers in the electrical utility field are discussed in the light of projected developments in automation and nuclear power.

THERE IS A WIDE VARIETY of new opportunities in engineering which did not exist 10 years ago. These opportunities apply to the young engineer, the future engineer, and also to the engineer who has been in the business for some years.

The explorations to be made here into the engineering future will be limited to two fields: the first, automation; and the second, nuclear energy. These two subjects were chosen because automation is part of the means to produce more and better quality goods from mechanical effort in place of human effort, and because nuclear energy is the coming source of the increased power needed for increased production. Both of these subjects will be discussed in this article primarily with reference to the electrical utility industry.

Any look into the future should be based on where we have progressed up to the present time. What has been the effect of mechanization and power on the country in the 20th Century?

Fig. 1 shows gross national output, the energy consumption, and the number of engineers employed from 1910 to 1950. These bench marks represent the past and the present in our national economy. The extrapolation into the engineering future begins where these stop.

The record of productivity as shown by the gross national output curve is remarkable. It has brought to our nation a standard of living hitherto undreamed of in history.

It is a record that has been and is being studied intently not only by Americans but also by citizens of other parts of the world. Our future record of productivity may be the key factor in our struggle for survival in a divided world.

The principal ingredients of our productivity are scientific and technical knowledge, research and development activities, and management techniques. We can explain our growth in productivity during the first half of the century as a continuation of the industrial revolution which substituted machinery for animal and human muscle, upgrading many unskilled laborers into the semiskilled machine operators of today.

The energy consumption curve is a measure of this mechanization. In 1955, industry consumed electrical energy at the rate of 9.7 kwhr per man-hour of human effort.

The last curve represents the number of engineers employed in industry. They are the ones who designed the power-driven machines which produce more national product with fewer man-hours.

In the second half of our century, we shall see an increasing substitution of machinery not only for human effort, but also for certain types of mental effort now performed by people. In the electrical utility industry, there has been a constant and ever increasing use of machinery and automatic equipment.

AUTOMATION

AUTOMATION is one of those words which means many things to many people. To many it is something like black magic which cannot be understood. I look on it as a simple extension of the tried principles of mass production which have carried us to the present stage in our standard of living. Machinery has been used in increasing amounts to relieve man of the burden of physical labor. Gradually, through automation, the analyzing of facts and the controlling of processes is being done mechanically or electrically instead of by mental effort.

Let us think of automation in connection with an electric generating station. The original Pearl Street Station in 1881 generated only a few kilowatts and took a lot of manpower to shovel the coal, control the voltage, and keep the machinery in working condition. We have made much progress since that time, adopting larger units, stoker firing, and many other mechanical processes, but the parade has not stopped.

A generating station built about 30 years ago with the equipment and of the design current at that time requires about one man for operation of every 800 kilowatts of capac-

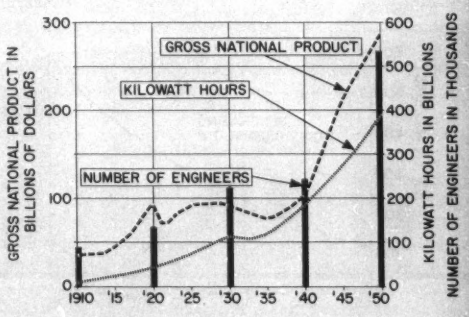


Fig. 1. Growth of gross national product, kwhr output, and number of engineers, 1910–1950.

Essentially full text of an address presented at the general session of the AIEE Great Lakes District Meeting, Fort Wayne, Ind., April 16–18, 1956.

T. G. LeClair, AIEE past president (1950–51), engineering assistant to the vice-president, Commonwealth Edison Company, Chicago, Ill.

ity. A station built today incorporating modern equipment and concepts of design requires about one man for every 2,500 kilowatts of capacity, roughly a 300 per cent improvement in manpower utilization over the period. This is only one of the means to higher pay without increasing product costs.

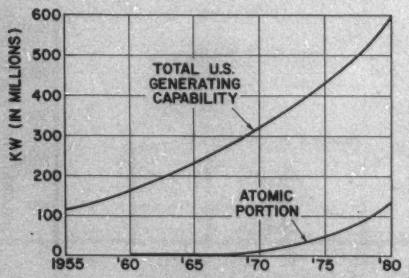
For example, it has been found possible to build stations on the unit system with the boiler the same size as the turbine, and operating as a unit independent of any other units in the station. After boilers got to be 10 stories high, a television gauge was installed so the operator does not have to climb to the roof to see the water level. Automatic combustion control is used so that the flow of fuel and the flow of air is adjusted continuously and more efficiently than a man on the control board could do it.

With the use of these automatic controls, it has been possible to concentrate the control for the turbine, the generator, and the boiler at a single point where it can be watched by very few men. This was not easy. It required the development of improved recording meters, telemeters, and control systems which operate directly from the reading of the meters.

Replacement of the operators' thinking under changing conditions by automatic control is the real essence of automation. In power generation, this automation has been extended to controlling the output of several generating stations from a central point by an automatic load control system which distributes the load properly among a number of stations.

The job has not yet been completed. Some of the more interesting problems are still to be solved. One of the toughest jobs in many power plants is cleaning the slag from boilers when it accumulates in unexpected places and plugs the boiler operation. Some good engineer must find a way to keep the boiler clean continuously. This will not only avoid a dirty job, but also will result in a far more efficient boiler plant.

Work is being done on more automatic machinery to measure the input of the coal and air to the boiler, the output of gas, and the output of electricity to make automatic heat rate computations. These automatic heat rates may some day be the means of continuously checking whether the plant is or is not operating normally. One or two power companies are trying load control systems which will automatically take into account the losses in transmission lines and the variations in efficiency of turbines at different valve points, and will readjust the control system the instant a unit is taken out of service.



Source: Electric Light and Power, *March 1, 1956*

Fig. 2. Power growth pattern, 1955–1980.

Electric utilities search for improvements in all facets of their industry. In the Commonwealth Edison Company, for example, automation is taking over a billing and bookkeeping operation involving more than a million Chicago customers. This new accounting system uses the IBM (International Business Machines Corporation) type *702* electronic data processing equipment. It is expected that by 1958, all of the bills of the 1.86 million customers in the Commonwealth Edison territory will be processed by automatic equipment. Savings under the new system are expected to be $750,000 per year before Federal income taxes.

Electronic billing climaxes a long history of mechanization in this company's accounting operations, which has included use of punched card equipment and use of meter reading cards that are read directly by machines.

The meter reading cards represented a great improvement over the meter reading books used in the past. But it is still necessary to go where the meters are located before the billing process can begin. Still to come is some cheap way of reading meters by a remote means.

We know that the electronic computer will prove useful in engineering computations. The computer has already solved some complex engineering problems. A team has been put to work studying the possibility of programming other engineering work. We are hopeful this will eliminate some tedious and repetitive engineering calculations.

SOCIAL EFFECTS

As engineers, we cannot avoid consideration of the social effects of automation. Every labor saving device for generations has been considered a threat to employment. It is hoped that this notion is being exploded, because we should know from experience that cutting costs makes for more demand of the product. Our fastest progress has not released people fast enough to fill the new jobs that are thus created. Commonwealth Edison, for example, has been using more and more automation, but has not had any layoffs of people even for abrupt changes. It has been found that automation can be integrated into the work through careful planning without serious dislocation of employees.

Progressive automation in the utility industry shows we still maintain a high level of employment at high wages. The customers now get three times as many kilowatt-hours from the same number of employees as 20 years ago.

One of the effects of automation will be to upgrade semiskilled operators into more highly skilled technicians with higher incomes. We can predict that increasing automation will require more workers who are better educated—people who can think, use judgment, and create.

Automation will have an impact, too, on management and on engineers. Executives of the future will find demands for better and more accurate judgments, and for the capacity to inspire and lead others in truly creative endeavors. It is obvious that broader qualifications will be needed in addition to technical competence.

NUCLEAR ENERGY

THE SECOND TECHNOLOGY destined to play an important part in our engineering future is that of nuclear energy.

It is only 13½ years since the theory of fission was proved through the operation of the first reactor at the University of Chicago. The 60 megawatt Westinghouse-Duquesne plant is now under construction. The Commonwealth Edison Company is planning to have the 180 megawatt Dresden Nuclear Power Station in operation by 1960. Hundreds of engineers will work on this one project alone before it is completed. The few of us who pushed so hard to get it started are about to be run over by its speed.

As many of you know, a panel of authorities recently reported the results of its 10-month study of the peaceful uses of the atom to the Joint Congressional Committee on Atomic Energy. Fig. 2 illustrates the prediction made by the Committee as to what the atomic power growth pattern for the next 25 years may be.

The Committee believes that atomic power generation will be competitive by 1965. By 1980, it is estimated that the proportion of atomic power may be about 25 per cent of the total. This percentage may sound small, but it should be pointed out that this is in terms of 1980. The atomic electric generating capability may, by that time, be equal to the present total generating capacity in the country.

Fig. 3 is an estimate of the engineers who will be needed by the atomic power industry. By 1975, a total of 50,000 to 70,000 engineers may be required.

SOURCES OF ENGINEERS

IN 1955, there were about 5,000 engineers and scientists working on atomic problems. About 400 of this total had received formal training in this field. The others were retrained on the job.

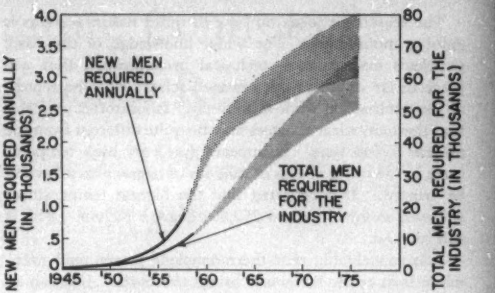
You may be interested in knowing how the nuclear energy team was formed at Commonwealth Edison. No specialists were hired specifically for this work. In finding technical talent to draw upon, any electric utility organization is a happy hunting ground. All kinds of specialists are required in its day-to-day operations. We had no problem in finding electrical, civil, and mechanical engineers, electronics specialists, and experts in economics and financial matters. We were pleasantly surprised to find that good engineers could be converted into first-class chemists and physicists by working with the national laboratories and studying the classified literature on reactor design. Some of these engineers and physicists are now recognized as equal to those trained from the beginning in these laboratories.

A team approach was used in tackling the complexities of reactor design. Probably to a much greater extent than in any other fundamental design problems, the various scientific and engineering specialities had to work in unison.

Nuclear power teams in many companies are successfully solving the problems of nuclear power, but major developments are still needed to smooth the path to low-cost nuclear power.

PRESENT TECHNICAL DIFFICULTIES

THEORETICALLY, nuclear power plants will eventually outstrip all of the present types of power generating plants.



Source: Nucleonics, *February 1956*

Fig. 3. Engineers required for the atomic power industry, 1945–75.

Some of the present technical difficulties are the following:

1. Design of a reactor capable of generating steam at pressures and temperatures used in today's modern turbines. As it stands now, present reactors represent a step backward —a return to the lower steam pressures of the past.
2. Allied problems, such as development of high temperature nuclear fuels, solving the problem of heat transfer from unbelievably concentrated sources of energy, and development of reactor materials capable of withstanding extreme heat and radiation corrosion.
3. Development of a low-cost fuel recovery process from used fuel elements.
4. Reduction in cost of reactor materials such as zirconium, beryllium, and heavy water.
5. Development of uses for fission wastes. The radioactivity of fission wastes creates a great problem in safely disposing of the wastes. Later, these products may turn out to be the base of a huge new chemical industry.

These are all potential fields, waiting for engineering pioneering.

Much of the present thinking about power reactors centers upon use of steam turbine-generator plants. Design engineers have already started in another direction—the use of gas turbines as prime movers. In this concept, the power reactor would be used to heat a gas such as nitrogen which, in turn, would be used to drive a gas turbine. Many present day power plant problems would vanish with the perfection of this type.

FUSION REACTORS

EVER SINCE the thermonuclear bomb became a reality, there has been speculation about the possibility of controlled thermonuclear power. At this time, it is not possible to predict *when* the thermonuclear reaction will be tamed for peaceful use. Right now, no simple means is in sight.

Our present apparent inability to harness this force should not stop us from including it as part of the engineering future. If we have learned one thing about predictions in the nuclear field, it is that many of them have been proved to have been unduly pessimistic.

The search for ideas on how to build fusion reactors is gaining momentum. The wider knowledge of the basic problems may cause a technical breakthrough that will place us far ahead in our research schedule. The reports of the unclassified work of university laboratories indicates that thermonuclear reactors may be quite different from the present fission type. It appears that very high temperatures in the order of tens of millions of degrees may have to be created. It is reported that the highest temperatures achieved so far are about 250,000 degrees Kelvin. This is still too low.

It is conceivable that thermonuclear power may eventually turn out to have very bright prospects. If it can be made to operate on the basis of hydrogen nuclear fusion into helium nuclei, the inexhaustible supplies of hydrogen gas could be used as fuel. It is possible that this kind of reactor could operate with less shielding and without fission products emitting large amounts of radioactivity. Regardless of whether thermonuclear energy becomes a factor in power plant design, sound and impressive progress towards the use of what we know now has been made.

To date, 44 companies are participating individually or in groups in building reactors for power sources. More than 300 million "private" dollars are involved in these efforts to lower the cost of power to the public. Total generating capacity for the nine reactor plants so far announced is 1,112,500 kilowatts.

It is evident from the record that the utility industry is making courageous progress in pushing nuclear energy development even though there is the definite hazard of rapid obsolescence of initial atomic power installations. The industry feels a strong obligation to its customers to go ahead and develop atomic power plants while, at the same time, it is making great strides in increasing the efficiency of fossil fuel use. Atomic power will certainly be exploited as a source of power as fast as the development of the art justifies.

CONCLUSION

This country has enjoyed a position of leadership in the world for many years. It is going to be a battle to preserve this leadership and the engineers have a big place in the battle. If we are to raise the standard of living, there must be more production. This implies a demand for an increasing number of engineers to develop the machinery for automation; it implies the need for more engineers to produce nuclear power. What is perhaps equally important, the use of the more complex machinery will produce more output for each worker. However, the worker will have to acquire an increased skill to operate the more complex machinery. The educational process is not confined to the engineer.

We are still on the upward trend in the need for technically trained people. In 1910, about one person in 250 employed in industry was an engineer. This number increased to about one in 100 in 1955. This percentage must be further increased to keep our leadership.

These new engineers are going to have more complicated and more interesting jobs to do than those of us who have been in the business for 30 years. The future for engineers is unlimited.

Electron Microscope Aids Petroleum Research Program

Scientists of the Atlantic Refining Company are using the most powerful electron microscope developed by the Radio Corporation of America to speed and broaden research on petroleum products.

The RCA type *EMU-3* electron microscope—so powerful that under its magnification a dime would be enlarged to a diameter of over three miles—has been installed in Atlantic's Philadelphia, Pa., Research Laboratories. It is being utilized in the research and new-product development of lubricating greases, waxes and catalysts, according to Dr. H. W. Field, vice-president and general manager of Atlantic's Research and Development Department and R. A. Teare, manager, RCA Industrial Products.

In the photograph at the left, Dr. R. S. Simard, director of Atlantic's Philadelphia Research Laboratory, watches as Alfred Baltz, microscopist, operates the microscope.

Grease technology is being extended importantly by electron microscopic study of the effects of processing variables, such as composition temperature and degree of mechanical work, on the structure and quality of greases. Examination of soap fibers in grease at the high resolution and magnification possible with the electron microscope provides new insight on the effects of these variables in grease manufacture and performance.

Power and Temperature Control of Pressurized Water-Cooled Reactors

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Control requirements for nuclear reactors of the pressurized water-cooled type are discussed. Embodiments of the systems required for a central station plant and for a ship's propulsion plant are described.

ANALYSES AND EXPERIENCE gained in the operation of water-cooled power reactors have clearly indicated a shift in the requirements for reactor control. Whereas it was once believed that fast, accurate regulation of reactor power as measured by nuclear instruments was required for any reactor, it is now known that water-cooled reactors can be designed to be self-regulating in power. Coolant temperature is adjusted during power operation by the poison rods in the reactor. It is the purpose of this article to state the basis for these conclusions and to describe the reactor control problem, in general, for water-cooled reactors. The pressurized water reactor controls are an example of the use of a temperature regulating system.

For a mobile reactor plant—for ship propulsion, as an example— a system which regulates reactor power in accordance with steam plant demands is described. Although the latter system is more complex, its close regulation of power affords certain advantages for propulsion plants.

Fig. 1 is a schematic representation of a reactor plant. In one or multiple closed circulating loops, water is circulated through the reactor as a heat source, thence to the steam generator by special pumps. From the steam generator, steam is delivered to one or more turbines and the condensate recirculated to the boiler. Operating as a surge tank on the primary coolant system is the pressurizer. Temperature changes in the coolant and the resultant volume surges are absorbed in the pressurizer and by system pressure changes. Current pressurizer designs use electrical heaters to keep the water in the pressurizer at the saturation temperature for the system pressure required. The steam bubble then in the top of the vessel acts as a cushion for pressure surges. Further reduction in pressure surges may be achieved by running a fine spray of cooler water into the top of the pressurizer vessel. The size of the pressurizer, however, influences the magnitude of pressure surges. Accordingly, pressurizer design is a major influence on the choice of the control system and its parameters.

For convenience, the temperature of the water leaving the steam is designated T_h, the hot-leg temperature. The water leaving the steam generator is designated T_c, the cold-leg temperature. The average temperature of the coolant in the reactor is a convenient parameter. The only measure of this, however, is $(T_h+T_c)/2$ which is designated T_{avg}. T_s is the temperature of the saturated steam at the boiler secondary outlet.

The programming of temperatures as a function of power level is important to the control system designer. For reactors with a negative temperature coefficient, maintenance of the average temperature at a constant value is desirable. The reactor itself tends to maintain this programming during power changes. Fig. 2 depicts the constant average temperature programming. Of even more significance than the T_c and T_h characteristics are the steam temperature variation and the consequent steam pressure variation. The variable steam pressure program is, of course, contrary

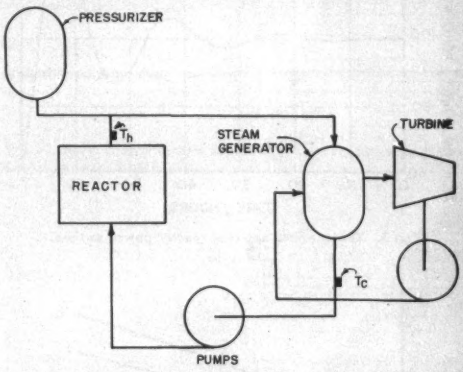

Fig. 1. Schematic diagram of a pressurized water-cooled reactor.

to normal power plant practice of maintaining the steam pressure at a constant value. Maintenance of constant steam pressure, on the other hand, would require wide variations in primary coolant temperatures and, as a result, would cause an increase in pressurizer size.

DYNAMIC PERFORMANCE AND CONTROL PROBLEMS

Static and Dynamic Performance Requirements. The design of a nuclear power plant as indicated previously includes the

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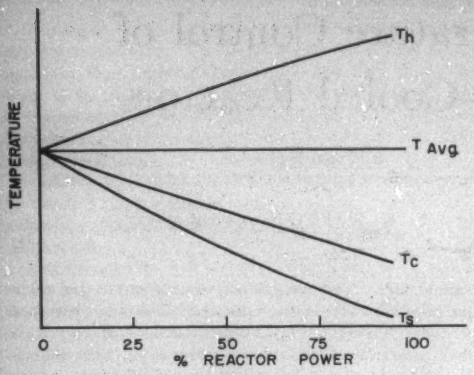

Fig. 2. Temperature vs power—constant average temperature.

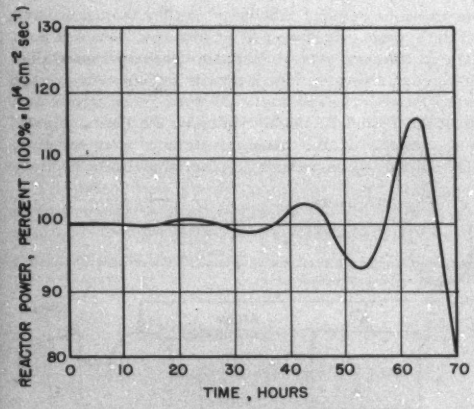

Fig. 3. Xenon effect, showing reactor power vs time.

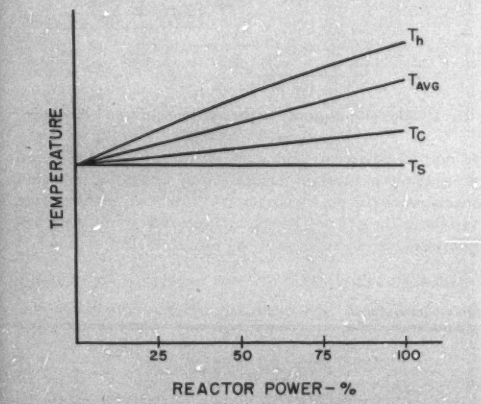

Fig. 4. Temperature vs power—constant steam temperature.

specification of an operating program of plant temperatures and pressures as functions of power level, in the steady state. In order to guarantee operating conditions for which the plant was designed, this steady-state program must be maintained.

Changes in steam load, of course, require that the reactor power be changed to meet the demand. During such transients the plant temperatures and pressures will deviate temporarily from the specified program. Plant limitations impose limits on the permissible range and on the rates of change of these plant variables. The plant then must respond satisfactorily to changes in load demand without exceeding design limitations.

Plant malfunctions which may occur during operation could lead to permanent damage to the system and present a hazard to personnel. The system must be capable of protecting itself against such accidents.

Summarizing the performance requirements, the system must:

1. Maintain a prescribed temperature and pressure program in steady-state operation.
2. Respond satisfactorily to changes in load, without exceeding plant limitations.
3. Protect itself against accidents.

Inherent Reactivity Feedback. The reactivity, the variable which controls reactor power, is affected not only by external means of control, but also by the inherent characteristics of the reactor. Before determining the amount of automatic control required, one must first analyze the inherent reactivity feedback effects.[1] The inherent contribution to reactivity variations is primarily a function of the fuel concentration, the concentration of xenon, and the state of the coolant.

Depletion of the fuel during the life of the plant tends to decrease the reactivity continuously. Here depletion refers to both uranium consumption and long-term fission product poisoning. It is this depletion effect together with the amount of control reactivity available which determines the lifetime of the reactor.

The concentration of xenon is a nonlinear function of the power level. Variations in concentration occur very slowly, the characteristic time constant being in the neighborhood of nine hours. Although the effect on reactivity is slow, the magnitude of the effect is quite significant and presents a serious control problem. Furthermore, it has been shown that unless the negative temperature coefficient is large enough, the feedback effect of xenon causes instability.[2] Fig. 3 shows this instability for a reactor having a negative temperature coefficient which is only 10 per cent smaller than the value needed for stability. Instability at such a low frequency is important only in plants which are expected to regulate themselves over long periods of time.

The equilibrium concentration of xenon is almost independent of thermal flux level, for values greater than 10^{13} cm^{-2} sec^{-1}. The effect of equilibrium xenon on reactivity varies from one reactor to another, and amounts to between 0.03 and 0.06 (reactivity). After starting up a reactor, initially free of xenon, reactivity compensation must be made

continuously for many hours as the xenon concentration builds up to its equilibrium value. In equilibrium, the rate of xenon production is equal to the rate of burn-up and decay. If the reactor is suddenly shut down, the burn-up rate goes to zero. This causes the concentration to build up to values which exceed the initial equilibrium value, before finally decreasing to zero. The maximum transient concentration, relative to equilibrium, is approximately proportional to the design flux level and amounts to a ratio of 5 for 10^{14} flux. If the reactor is started up at peak xenon, the burn-out effect predominates and is proportional to the product of flux level and concentration. Thus, the maximum burn-out rate is proportional to the square of the design flux level. At 10^{14} flux the maximum xenon reactivity rate is in the neighborhood of 0.5×10^{-4}/sec to 10^{-4}/sec. Xenon reactivity rates of this magnitude equal or exceed rates needed for control of power transients. Thus, transients in xenon concentration often present the most serious control problem.

The problem of start-up is complicated because of the exponential behavior of a reactor. Start-up transients involve many decades of flux level beginning at the shutdown level determined by the extraneous neutron source strength and the degree of subcriticality and extending into the operating power range. Care must be exercised so as not to obtain too fast a reactor period (inverse logarithmic derivative) as the operating power range is approached. When reactivity is inserted at a constant rate the period obtained depends primarily on the reactivity rate, and also on the initial amount of shutdown reactivity, source strength, and the mean neutron lifetime. The safety problem is minimized and the amount of instrumentation required may be reduced if the reactor has a strong negative temperature coefficient of reactivity. When power transients enter the operating power range, the degenerative feedback of the temperature rise limits the peak power obtained.

The effect of the state of the coolant may be described in terms of a temperature coefficient of reactivity and a pressure coefficient of reactivity. Any nuclear dependence on temperature may be lumped into the temperature coefficient.

The pressure coefficient is positive, introducing regenerative feedback which implies a stability problem. Fortunately, the pressure coefficient is usually small and a pressurizer is employed to reduce pressure variations. Nevertheless, the effect can be significant in plants where pressure is permitted to vary over a wide range and in boiling reactors where there is a strong dependence on pressure.

The temperature coefficient is usually negative, introducing degenerative feedback. Reactors with a negative temperature coefficient of reactivity are more easily controlled, because of their tendency to regulate themselves. The effect can be sufficiently strong to permit changes in power level with no external control of the reactivity. The characteristic time constant of this type of control is a function of the primary-loop circulation time.

A Spectrum of Control Problems. Considering the performance requirements and the inherent reactivity feedback effects, one finds that the control problems may be subdivided on a

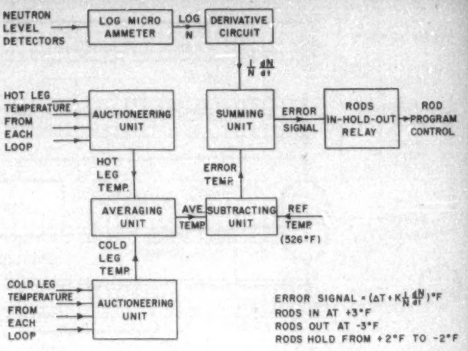

Fig. 5. Reactor power and temperature control system for pressurized water-cooled reactor.

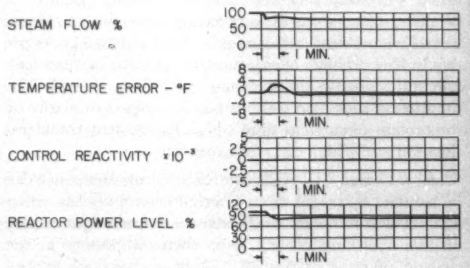

Fig. 6. PWR control system response to step reduction in steam load from 100 to 84 per cent.

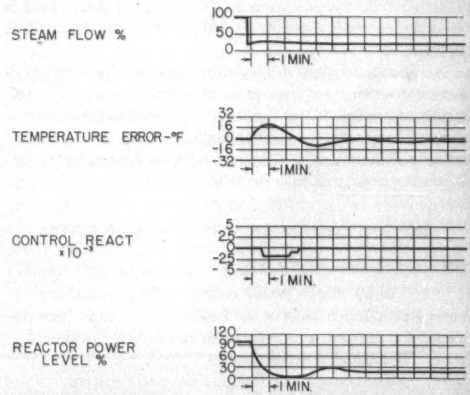

Fig. 7. PWR control system response to step reduction in steam load from 100 to 25 per cent.

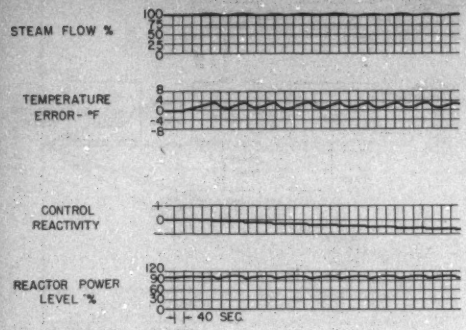

Fig. 8. PWR control system response to fixed-rate change in reactivity.

frequency spectrum. Compensation for fuel depletion requires extremely slow reactivity adjustment. Control of xenon transients requires faster compensation and introduces a stability problem in the neighborhood of 1 to 2 cycles per day.[3] The problem of adjustment to changes in steam load falls still higher in the spectrum of control problems. The duration of such load transients is determined primarily by the coolant circulation time. Finally, accident considerations fall at the high end of the spectrum.

Means of Control. All of the control problems mentioned can be handled by means of an external control system, either manual or automatic. Such external control might employ neutron-absorbing control rods, chemical poisons in the coolant, or reflector control. Early reactor-plant control planning, which has led to present day control systems, involved these external means for all of the control problems.

As analyses progressed and operating experience was obtained, it was found that reactor plants exhibit a fair degree of self-regulation. Through the temperature coefficient of reactivity, the system response to changes in steam load is satisfactory even when no external reactor control is applied.

An economic plant design must optimize the costs of inherent control means, such as burnable poisons and temperature coefficient and the costs of the external control system. Complexity and reliability enter into such an optimization, inasmuch as they affect maintenance, insurance, operating costs, and firm demand rates.

CENTRAL STATION REACTOR CONTROL SYSTEM

Requirements of the Steam Plant

1. *Steady State.* Most central station steam-electric energy-production units of the fossil-fuel type have been designed for constant steam pressure at all loads in the steady state. The benefits derived are:

(a) More economical design of the steam system.
(b) Simpler throttle governor control.
(c) Better control of thermal energy storage problems on rapid load reduction.
(d) Better boiler feed-water control because of the elimination of variable head.

Although these objectives are desirable, they are not overriding considerations that prevent design of a steam turbine system in which steady-state steam pressure is variable with load. The steam pressure is regulated by the combustion control equipment to close limits. The needed result is a generator output held within ±1 per cent of rated value. If the steam pressure were not closely regulated, then the throttle would need to be adjusted to maintain generator output with a consequent cascading of control systems, each affecting the other. Such a system would be difficult to stabilize.

2. *Transient.* Load-change requirements for a central station turbine are not, in general, as severe as they are for ship propulsion. The high-efficiency low-clearance turbines will not take large rapid increases in load as routine practice. The load changes for which the reactor control system to be described was designed are approximately as follows:

(a) ± 20 per cent as a step change.
(b) ± 25 per cent at 0.5 per cent per second.
(c) Full load range increase or decrease achieved in steps of the foregoing magnitudes, steps spaced to provide an over-all rate of 3 per cent per minute.

These load changes are part of the daily load variations imposed on the steam-electric generating unit by the electrical system load. The variations are of two types:

(a) A one cycle per 24-hour-day increase and decrease of load.
(b) A minute-by-minute variation of load superimposed on the daily load cycle. These variations are usually much smaller in their effect on any unit than the ± 20 per cent step change given in the foregoing. This value may result one or more times a day as a result of a coincidence of normal system variations.

In summary it may be said that all normal short-time load variations are relatively low in magnitude, not exceeding 20 per cent. Abnormal, rapid load changes of larger magnitude may occur in a downward direction as a result of electric system changes, causing loss of external station load.

Requirement of the Reactor Plant

1. *Steady State.* A steam pressure that remained constant at the turbine throttle as load changed, would require of the primary plant that the average temperature of the water change with load (Fig. 4). The major effect on the reactor plant is that of requiring a large expansion volume in the pressurizer.

Conversely, if reactor plant average temperature were maintained constant at all loads, as shown by the curves of Fig. 2, a more economical pressurizer could be used. This temperature program was selected as the basis of design for the control system described later.

2. *Method of Load Change.* A reactor must be made to change its load by a temporary upset in the criticality relationship.[8] The positive or negative reactivity insertion

needed to enable the nuclear fission rate to proceed from one level to the next must be removed as soon as the new level is reached. Inasmuch as this temporary upset can be inherently and unassailably provided by the negative temperature coefficient of reactivity, there is a fairly compelling argument in favor of its dominant use for load transients. That is to say, the control system and the primary plant should be designed to allow the temperature coefficient to make at least the major portion of the nuclear level adjustment without assistance from rods moving in or out on a load change, and then returning to their original position. The disadvantage of this approach lies in a more sluggish response, especially present in the case of large load changes.

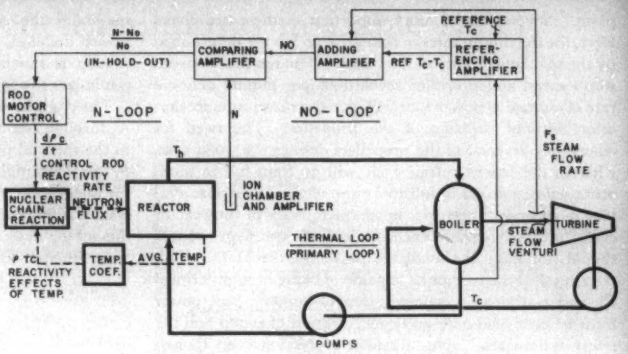

Fig. 9. Power and temperature control for a mobile reactor.

Power and Temperature Control System. The system is shown in block diagram form in Fig. 5. Since average temperature is to be maintained constant, the system measures the temperature of the water at reactor exit, of the water leaving the boiler, averages them, compares the average to a reference, and moves rods in response to the error signal thus created. Because of the desire for stability of the electric generator output at a given throttle setting, a band of ±3 F is chosen for control limits. This band is restrictive in its requirements on temperature measuring element reproducibility. However, if the needed reproducibility of these elements is not realized, the band can be relaxed to ±5 F without great loss in electric generator output stability.

Even with a control band several times wider than the ±3 F or ±5 F discussed, a damping signal is needed for reactor stability because of the high reactivity control rates required of the rods for xenon transients under most severe conditions. The damping signal used is rate of log-nuclear level change.

The complete control signal then becomes:

$$\text{Error (in degrees F)} = \frac{T_h + T_c}{2} - K\frac{d}{dt}(\log N) - T_{ref}$$

$$= \frac{T_h + T_c}{2} - K\frac{1}{N}\frac{dN}{dt} - T_{ref}$$

The constant K is a conversion factor to change log N units to degrees F and to adjust the gain of this portion of the signal.

The advantages of the foregoing system are:

(a) It is not dependent on the absolute accuracy limitations of either steam flow or nuclear level measurements.

(b) The reliability of the source elements in the control system is high, particularly with reference to the nuclear signal. In pressurized water reactors (PWR), with four T_h and four T_c measurements to choose from, only one of each will be used; these will be the highest auctioneered values.

(c) The rate of log-level change is most appropriate for providing for reactor stability because of its rapid response to reactor changes. For this reason also, it is most sensitive to reactivity changes produced by inadvertent rod motion or water temperature transients created by loop valve and pump operation.

(d) Lacking a steam flow signal, the system does not respond immediately to low magnitude load changes but allows the temperature coefficient to change the load.

(e) By using T_c at the boiler exit, large load changes, such as for sudden loss of all or most of the load on the steam plant, will produce a strong control error signal before the temperature coefficient can make a change.

(f) Xenon reactivity changes, producing temperature errors as their first and most pronounced effect, are corrected by the temperature measuring system.

Predicted Performance. Figs. 6 through 8 show electric analogue simulator results for this control system. The temperature coefficient assumed for these curves is -1×10^{-4} per degree F. Coolant flow is 100 per cent. Fig. 6 shows the response of the system to a step reduction in steam load demand of 16 per cent. The curves show steam flow, average temperature error, damping signal strength, control reactivity insertion, and reactor power. No control reactivity change was required. Fig. 7 shows a step load reduction of 75 per cent. Control reactivity change was initiated by the system to assist the temperature coefficient.

Fig. 8 shows the response of the system to a fixed rate of change in reactivity that might be produced by a xenon reduction following a load increase.

MOBILE REACTOR CONTROL SYSTEM

Operational Requirements. The operational requirements of a mobile nuclear power plant for ship propulsion distinguish the control from that of a control station nuclear power

plant. Several of the more important of these are given. First, the maximum rates of change of power are determined by the maneuverability of the vessel. The relation between ship's speed and propeller revolutions per minute define a rate of change of power that will give the maximum acceleration without slippage of the propeller. The need for emergency reversal of the propellers defines the worst case, wherein the power output cycle will go from full to minimum self-sustaining to full in a time of the order of several tens of seconds. Second, the characteristics of the reactor core, primarily the concentration of transient xenon, should not limit the available power of the plant. This requires that the reactor be capable of being brought critical with any attainable concentration of xenon. Full power must be produced with any concentration of xenon and the safety system must give adequate protection even though the xenon concentration may produce flux pattern distortions and consequent "hot spots" within the core. Third, the large and rapid disturbances in reactivity following a change in power level resulting from the changing xenon concentration must be overridden by the control system so that plant maneuverability is not prejudiced.

Temperature Method of Control. The design of the reactor power and temperature control may follow two different methods. The first is to oversize the pressurizer so that the increases in reactor temperature will expel water from the core with a relatively small accompanying pressure surge. Since the temperature coefficient of reactivity is primarily dependent upon the expansion of water as the temperature increases, this system permits a power change to be effected by the temperature coefficient; the control rods need not be moved. The control system moves rods only in response to changes in reactor temperature; the reactor power control is built into the reactor, pressurizer, and boilers. The method provides a simplified control system but places requirements on the design of the pressurizer and the core with respect to requiring a minimum temperature coefficient, and upon the entire plant since relatively wide transient swings in reactor temperature and steam pressure are experienced.

Power Regulation Method. A second method of control has been utilized where no essential dependence is placed upon the temperature coefficient (Fig. 9). This method utilizes a computation of the required plant power from measurements of steam-flow rate and reactor temperature. The generated power is held equal to this by a measurement of the flux level and positioning of the control rods. The resulting control system utilizes more components but closer transient and steady-state temperature regulation is possible, the transient peaks in power level are reduced, and the requirements for the pressurizer and core designs are reduced. The result is a more flexible control system adaptable to a wide variety of reactor plants and operating conditions.

This method of control is illustrated in detail by the example in Fig. 9. The system consists of a minor closed loop, the N-loop, and a major closed loop, the N_0-loop. The N-loop controls the nuclear chain reaction by moving the control rods through an in-hold-out rod control. This maintains the generated nuclear power, N, equal to the power demand, N_0. The characteristic frequency of the N-loop is much higher than that of the N_0-loop which minimizes the interaction effect on control system stability.

The N_0-loop controls the generated nuclear power level, N, through the N-loop so that the generated power is equal to the thermal power as measured by the steam flow signal F_s and maintains T_c near the reference value. Reset (or integration) of the T_c signal is not used inasmuch as the system is more stable without reset. The errors in calibration of F_s and N are not large enough to require reset. The principal control equations are:

$$N_0 = K_1 F_s + K_2 \text{ reference } (T_c - T_c)$$

$$\left|\frac{N_0 - N}{N_0}\right| < a, \quad \frac{d\rho_c}{dt} = 0$$

$$\frac{N_0 - N}{N_0} > a, \quad \frac{d\rho_c}{dt} = +b$$

$$\frac{N_0 - N}{N_0} < -a, \quad \frac{d\rho_c}{dt} = -c$$

Where

ρ_c is the reactivity of the control rods

$\frac{d\rho_c}{dt} > 0$ represents rods moving out of the reactor core

$\frac{d\rho_c}{dt} < 0$ represents rods moving into the reactor core.

As shown in Fig. 9, the temperature coefficient of reactivity represents an interaction between the N and N_0 loops. A negative coefficient reduces the characteristic frequency of the N-loop and is a stabilizing quantity. The system is, however, adaptable by adjustment of the constants in the control equations to a wide variety of reactor plants. Equipment requirements for this system have been described previously.[4]

SUMMARY

CHOICE OF PLANT PARAMETERS, such as temperature programming, pressurizer size, and reactor design parameters affecting temperature coefficient, have been shown to determine requirements for the reactor power and temperature controls. The controls for a central station and mobile reactor have been described, indicating the extremes in what would be required for manual or automatic control, one a simple temperature reset and the other a power-regulating system. Application of the reactor necessarily leads to the choice of the system and determines its operational requirements.

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Charging-Current Limitations in Cable Lines

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THE CAPABILITY of high-voltage cable lines to deliver power diminishes rapidly as the length of line increases. This is shown in Fig. 1 which is valid for the cable sizes commonly used for operation at 132 kilovolts and higher voltages. Rough approximations for general use may also be taken from these curves for 66-kv cables, but new curves would have to be prepared for greater than 15-per-cent accuracy.

The envelope of the family of curves in Fig. 1 shows that the magnitudes of the diminishing maximum permissible values of power output occur at diminishing values of lagging load power factor as the length of the cable line increases. In constructing these curves, the 3-phase thermal rating of the cable-line as determined from its maximum permissible conductor current and its nominal system voltage was taken as the base power. The base length of cable line equals the length of cable line whose charging current is equal in magnitude to the maximum permissible conductor current.

For a 2-million circular mil, 220-kv, pipe-type cable installed under conditions which limit its rating to 250,000 kva, the base length is 29 miles. A similar 66-kv cable line would be rated 110,000 kva, but its base length is 61 miles since its charging reactive power per mile is only one fifth that of the 220-kv cable. Therefore, the maximum transmission distances for high-voltage cable lines are less than those permissible at lower system voltages. This is in marked contrast with the experience with aerial transmission lines where higher system voltages allow greater transmission distances.

The permissible range of power output becomes limited as the length of the cable line approaches the base length. A line of 1.0 per unit length may deliver no power to a unity power factor load nor to any leading power factor load. As the length of the cable line is extended beyond the base length, only lagging power factor loads may be supplied and the cables would be overloaded not only if they were permitted to deliver any power at power factors whose values are greater than a definite value for each line length, but also if the power output were permitted to drop *below* a definite minimum value for each allowable power factor for the respective lengths.

The inherent charging reactive power of a cable line may be utilized to deliver vars to the system in varying amounts at both ends. This is shown in Fig. 2 which also provides a convenient measure of the capabilities of cable lines to transmit an excess in generation of vars, over and above those inherent in the cable itself, from the portion of

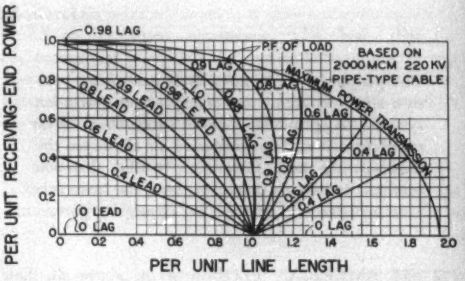

Fig. 1. Power transmission limits of high-voltage cable lines. Curved lines apply for sending-end current equal to rated or base current of cable; horizontal lines, receiving-end current equal to rated or base current of cable.

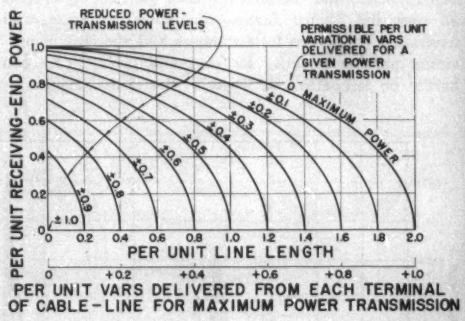
REDUCED POWER-TRANSMISSION LEVELS
PERMISSIBLE PER UNIT VARIATION IN VARS DELIVERED FOR A GIVEN POWER TRANSMISSION
MAXIMUM POWER
PER UNIT RECEIVING-END POWER
PER UNIT LINE LENGTH
PER UNIT VARS DELIVERED FROM EACH TERMINAL OF CABLE-LINE FOR MAXIMUM POWER TRANSMISSION

Fig. 2. Permissible variation in per unit vars delivered to electric system at each terminal of cable line for a given power transmission.

the system at one end of the line to the portion of the system at the other end. Since sufficient accuracy for illustrative purposes may be obtained, the series impedance of the lines was neglected when computing the values for this figure. Base vars, equal in magnitude to base power, are used as parameter of Fig. 2 in addition to base power and base length which were used in Fig. 1.

It can be seen that any cable line of 1.0 per unit length or longer may not transmit vars regardless of the magnitude of power transmission if the cables are not to be overloaded. This comes from the fact that the actual transmission of vars over the cable line can occur only when positive vars are delivered from the system to the line at one end and from the cable to the system at the other end.

Digest of paper 56-69, "Charging-Current Limitations in Operation of High-Voltage Cable Lines," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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San Francisco's Proposed Interurban Transit System

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MEMBER AIEE

The people by the Golden Gate are taking positive steps to create an efficient transportation system. A publicly owned interurban mass rapid transit system, designed to eliminate the time-wasting and hazardous traffic situation common to today's urban centers, has been recommended and is receiving strong support.

THE AMERICAN PEOPLE want, above all, their freedom—including freedom to travel at any time and place, and with great speed. The private automobile has given expression to this freedom of movement to the point that there is now in California almost one car for every two people in the state. The result in cities like San Francisco and Oakland has been the same as in cities all over the United States—congestion, irritation, and frustration. The loss in man-hours and the cost of providing parking facilities for so many private cars can hardly be estimated. It is plain that if the trend continues, the greatest advantage of the automobile, freedom to move as one pleases, will be lost.

It is only proper that the engineer should find the solution. At his command are not only the tools to do the job, but also the full understanding of the problem: "to move people rather than vehicles." Engineers are frequently called in to make specific studies of individual traffic problems, but seldom are they given the chance to study the problem as a whole for a large metropolitan area.

THE RAPID TRANSIT COMMISSION

FIVE YEARS HAVE PASSED since the San Francisco Bay Area Rapid Transit Commission was created by the California State Legislature. This body was set up with representatives appointed from each of the nine Bay area counties, half by Boards of Supervisors of the counties, and half by the Governor—26 men in all. There were no limitations or restrictions on how the study should be made, except perhaps one—an initial appropriation of only $50,000 to do the job. This was barely enough to hire an executive secretary, open an office and complete a preliminary study analyzing the magnitude of the problem and presenting a program to follow. The Commissioners receive no pay and meet at least once a month at their own expense.

The first big step was to make a comprehensive study of the 7,000 square-mile area to determine where people live, where they work, to estimate the probable future growth and development, and from this information determine how the people of the area can best move about with the least personal inconvenience, at a reasonable cost. The Commission asked the State Legislature for approval of the plan with a suggestion that the State provide $400,000 of the cost and the nine counties $350,000. The plan was approved in June, 1953.

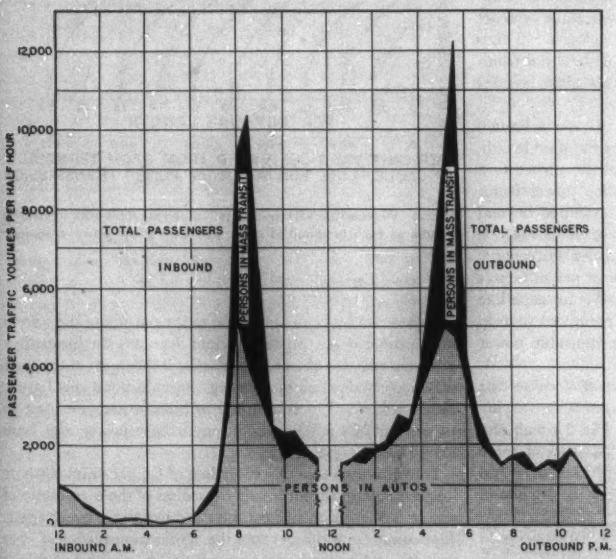


Fig. 1. Fluctuation of interurban traffic volumes during typical weekday at the San Francisco Peninsula Gateway, 1954.

A special article recommended for publication by the AIEE Committee on Land Transportation.

J. C. Beckett is chief engineer, Wesix Electric Heater Company, San Francisco, Calif., and a member of the San Francisco Bay Area Rapid Transit Commission.

MAKING THE STUDY

NEXT CAME A MAJOR TASK of the Commission, that of finding an engineering firm with sufficient experience and an unusual amount of perception to study the problem from many points of view—within a budget of $610,000. It was recognized that some of the qualified firms available were handicapped by having made limited studies in the Bay area before. Through no fault of their own they had been restricted to a study of a part of the problem, a subway for the City of San Francisco, a second Bay bridge crossing, or some single traffic bottleneck, without consideration for the over-all picture. Decisions in these smaller studies were necessarily made on the assumption that other conditions remained fixed, a mistaken notion of the governmental agency or group ordering the study.

Here was an opportunity the Bay area had never before had and might not soon get again: one complete comprehensive study of the entire metropolitan area, including its present needs and probable future development over the next 35 years. It is hard to change a decision already made public even though a new opportunity is provided to obtain more facts. The engineering firm for this study had to be one with no previous decisions to defend.

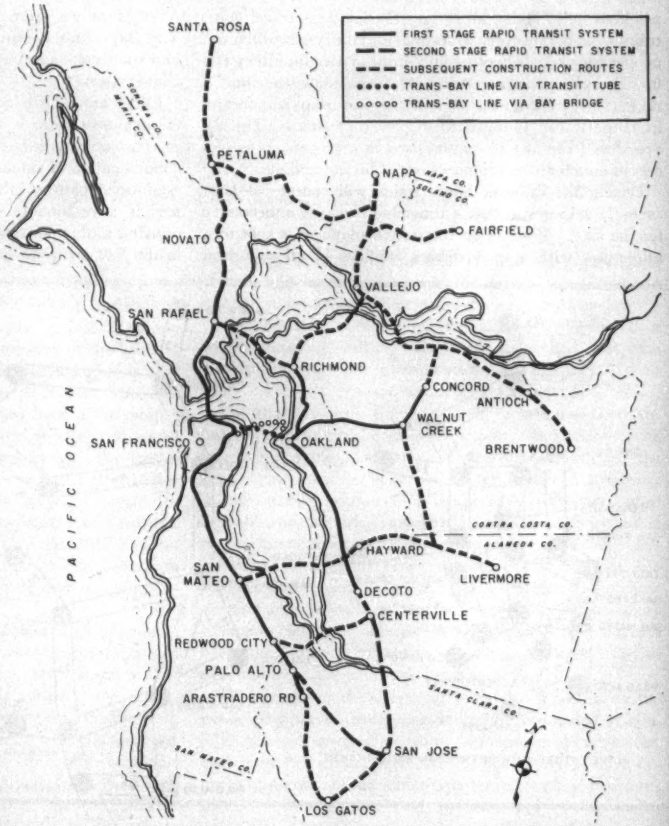
The partnership of Parsons, Brinckerhoff, Hall, and Macdonald of New York City met all of the requirements. They retained for their associates, at the Commission's suggestion, planning consultants, Adams, Howard, and Greeley of Boston, and transit engineers, Gibbs and Hill, Inc., of New York. The study required more than two years to complete, and took into consideration every known means of transportation, including Germany's monorail, and modern helicopters.

The Parsons firm did not withdraw into an ivory tower to make its study. Its representatives frequently met with the Engineering Committee of the Commission and gave a progress report at each monthly Commission meeting. Many engineers and executives judge such a procedure to be risky—too much chance for misunderstanding and for political opposition to set in before the study could be completed.

The Commission took the view that ideas must be aired while the study is in progress so as to draw out all possible viewpoints. The risk of confusion had to be taken if the report was to include the answer to all major questions and alternatives. This was not a study that would inevitably conclude with one possible solution. There are alternatives involving both public policy and the standard of living desired for the area. The engineer is frequently misunderstood on this point when asked to give a recommendation. One San Francisco newspaper stated flatly that the engineers must prove that their recommendation is the *only* reasonable solution. This newspaper seemed to think engineers are theorists rather than men applying technical skill, knowledge, and judgment to community problems.

THE RECOMMENDATIONS

THE FINAL ENGINEERING REPORT was completed on January 5, 1956. It contains a recommendation for a



Courtesy Parsons, Brinckerhoff, Hall and Macdonald

Fig. 2. Routes of the proposed San Francisco Bay area rapid transit interurban system, showing recommended construction stages.

123-mile interurban grade-separated mass rapid transit system involving $875 million to cover the first phase of construction, rolling stock, and interest charges of 2½ per cent. This includes costly downtown terminal facilities, an underwater tube, numerous tunnels, both subway and elevated structures, as well as suburban stations with large parking areas for automobiles. The report states that electric trains are essential in order to meet the peak requirements occurring twice each weekday (Fig. 1). These trains will operate at an average scheduled speed of 45 miles per hour, including station stops. This is accomplished by providing an arterial system with infrequent stops and using the automobile as the principal feeder, supplemented by local transit in the larger communities (Fig. 2).

It differs from any previous transit facility in that it is interurban in character and designed to compete with and complement the automobile. Stations are spaced an average of 2½ miles apart, with trains achieving 70 miles per hour and making all stops. During peak travel hours trains will operate every 90 seconds and the system will move people traveling between communities faster than they can now travel by private automobile, including the time it takes to get from home to the transit suburban station and from the transit terminal to the office or factory (Fig. 3). Speed and comfort are emphasized as prerequisites to success in enticing the commuter out of his automobile.

During the off-peak hours trains will operate at least every 15 minutes so that a timetable becomes unnecessary for the user. Waiting on the station platform is kept to a minimum, with ample parking facilities in all suburban station areas. The proposal is for a complete system serving the entire area and making it possible to move freely from one major section to another, with convenient transfer points in central areas. This is essential if "habit of use" is to become second nature for a majority of commuters.

GEOGRAPHY

GEOGRAPHY is an important consideration in any plan, particularly in the San Francisco area. Mountain ranges rise to more than 2,000 feet in many spots in the several counties. Most important, however, is the Bay itself lying geographically in the center of the greater metropolitan area. The Bay presents engineering problems in communications and travel, but in this case it has been an asset in the design of a rapid transit system. It is as if the Bay had been set aside years ago to limit congestion from concentrating in the central area. Thus, it is possible for two large cities, San Francisco and Oakland, to be brought within 11 minutes of each other. This is less time than it takes to get from uptown to downtown New York. The Bay forms a central open core *around* which centers and subcenters can be linked together with a simple trunk transit system.

Other areas have not been so fortunate. Los Angeles, for example, sprawls in all directions with no means of establishing a grade-separated network short of extensive condemnation of valuable improved property, and with no established pattern of major traffic movement which will permit a reasonable cost arterial system. The accompanying route map shows how the main gateways of travel in the Bay area can be served by a rapid transit system.

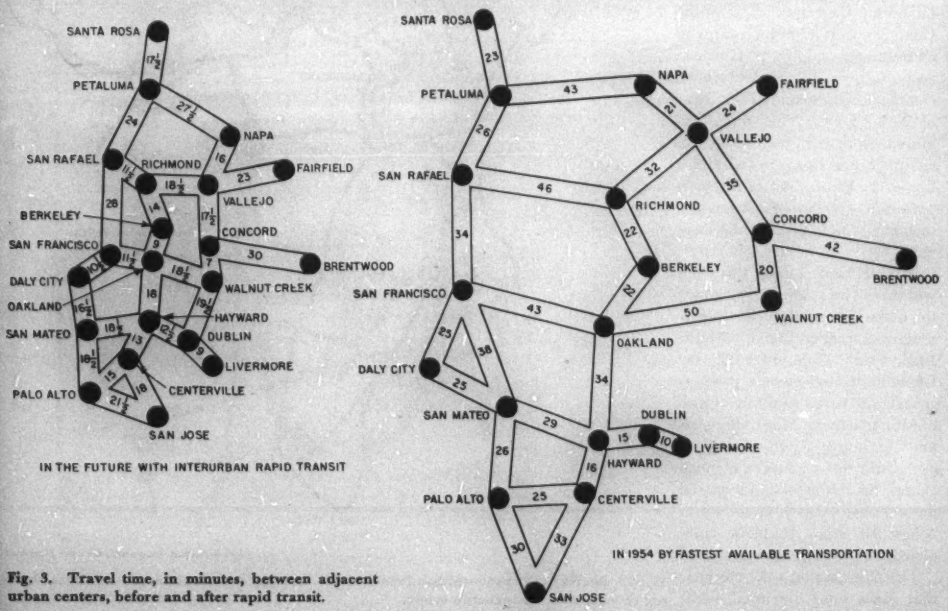
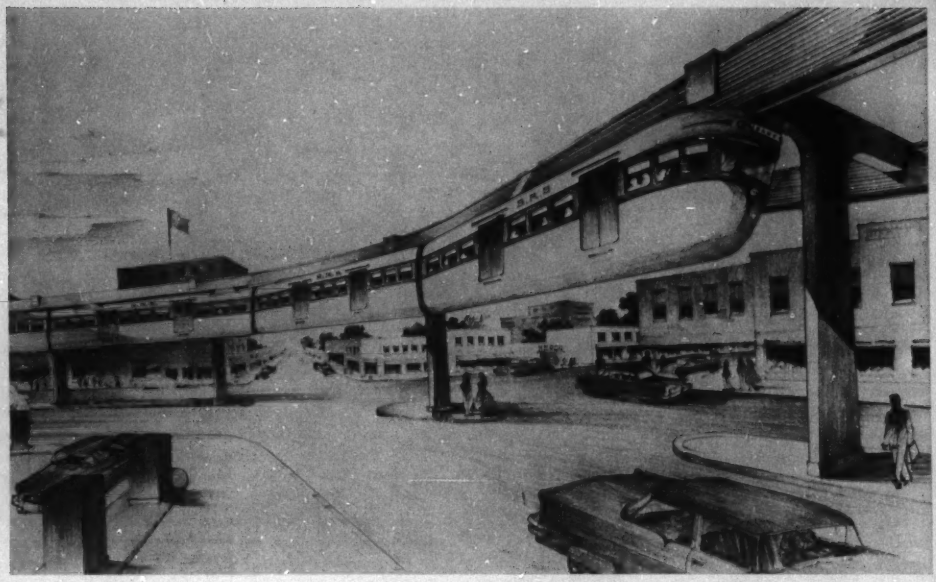


Fig. 3. Travel time, in minutes, between adjacent urban centers, before and after rapid transit.



Courtesy Gibbs and Hill, Inc.

Fig. 4. Artist's conception of suspended-train (monorail) system in operation.

ENGINEERING INGENUITY

PERHAPS THE MOST DRAMATIC FEATURE of the plan is the recommendation for a 4-mile long, $80 million underwater tube beginning in the financial center of San Francisco and extending in almost a straight line toward the heart of Oakland. The boldness of this recommendation is emphasized by the notation of the engineers that this would be the "optimum plan"—as distinguished from a "minimum plan" calling for use of the present Bay Bridge with necessary speed restrictions and a circuitous route. The cost of a subaqueous tube is quite reasonable as compared with tube construction for motor vehicles, because of the need for only two lanes of travel and no major ventilation problem. The underwater tube permits a convenient direct connection with the major subway system in San Francisco, with no serious differences in elevation and no speed restrictions.

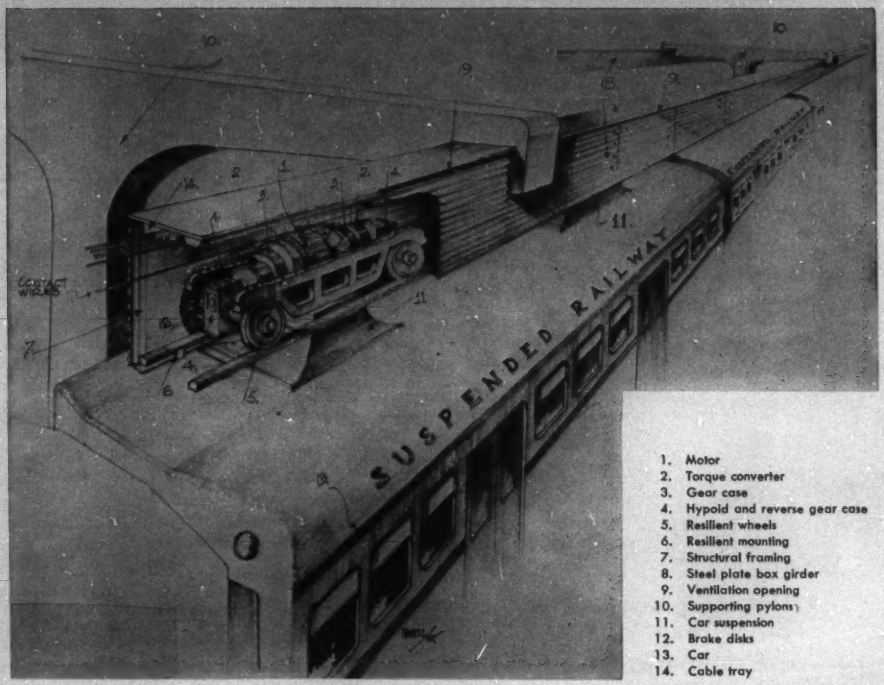
Modern subway construction is preferred in downtown areas where the cost of widening narrow streets for elevated structures is prohibitive. Engineers have learned that elevateds are esthetically intolerable unless given setting with ample space from other conflicting structures. Subways make it possible to build large terminal facilities adequate to handle the movement of thousands of people simultaneously. Large elevated terminals are awkward at best, and unless made an integral part of adjacent buildings are unsuitable for downtown locations.

In outlying areas, where elevated structure is to be used, it will be modern pedestal type of concrete supported along a center strip of the existing road with a minimum width of the road specified as 104 feet. In this way, obstruction of light will be minimized and the general appearance in relation to buildings will be attractive.

Two basic types of equipment have been considered, a conventional 600-volt d-c, electrically propelled train of a modern design, and a suspended or "monorail" train using 2,300-volt, 3-phase, squirrel-cage motors (Fig. 4).

For the Bay area the suspended system has been adjudged less desirable because of a lack of flexibility for an interurban system. This equipment cannot run on the ground; it must be supported on an overhead structure. There are numerous sections in the Bay area where fenced right-of-way initially is entirely suitable without going to the much more expensive alternative of overhead suspension. Perhaps in other urban centers such as Los Angeles the "monorail" system will be preferred since the existing arterial grid pattern there will make it mandatory to remain elevated. The Bay area however, is characterized by communities connected by routes paralleling the Bay or mountain ranges, with little cross traffic.

Of interest to the electrical engineer, however, is the proposed propulsion equipment for the suspended system. The cars are suspended from two narrow-gauge trucks, each equipped with a single 200-hp, 1,800-rpm, 3-phase, 60-cycle squirrel-cage induction-type motor, with a hydraulic torque converter connected to each end of the motor (Fig. 5). The induction motor comes up to speed very rapidly since the converter does not exert its maximum drag on the motor until the latter reaches a speed approximately 97.5 per cent of synchronous speed and well above



Courtesy Gibbs and Hill, Inc.

Fig. 5. Although suspended trains have not been recommended for the Bay area, this sketch illustrates a proposal for use of a-c drive with a squirrel-cage induction-type motor on each truck and hydraulic torque converters connected to each end of the motor.

the breakdown torque. Good acceleration is provided with complete elimination of a-c to d-c conversion equipment. This equipment is particularly adaptable to the suspended system with the box girder track structure because the proved desirable features of an overhead collecting system are neatly provided within the girder. The same electrical system can be provided for a conventionally supported train system without overhead structure, but the 3-phase pickup becomes complicated. In this study, unsightly wires and associated equipment were ruled out as unacceptable to the people of the area.

Electronic train control equipment has been included as essential to a modern transit system, thus ensuring the safety of operation on a minimum headway of 90 seconds. One man will be provided in a control position at the front of the train for continuous observation of the right-of-way ahead, with emergency procedures at his command to stop the train in the event of unusual situations. Normally the electronic equipment will control the trains' movements, including reduction of speed on curves, stopping, and berthing.

Communication by radio telephone between trains and dispatchers, passenger stations, power directors and substations is accomplished using ultrahigh-frequency radio stations. In the cost estimate $11,100 was included for communication and signaling equipment on each end car.

REDUCTION OF NOISE AND AIR POLLUTION

SERIOUS CONSIDERATION has been given to the desirability of keeping noise to a minimum. During the Commission's deliberations with the engineers, strong opposition was voiced by the Commissioners to any transit equipment that resembled existing facilities in other cities, both in appearance and noise. High standards were set to ensure against appreciable noise, either to the passenger or those located close to the right-of-way.

Pneumatic tires are being given serious consideration, with tests recommended to determine the noise level of modern steel wheels and the improvement which can be expected using conventional rubber tires with steel guide flanges (Fig. 6).

Though not mentioned in the engineers' report, the Commission is well aware of the desirability of electric propulsion as a direct means of eliminating a major source of air pollution. Automobile engines operating at low speeds or idling introduce enormous quantities of objectionable material into the atmosphere of our cities. This fact has been thoroughly substantiated in Los Angeles

where the automobile density is the highest in the world. Mass rapid transit for commuters will eliminate a large number of cars from coming into the downtown area and will reduce traffic congestion for those who must come in, thereby reducing the amount of toxic material generated from these cars by keeping them moving.

Modern cities have many problems, but two of the biggest are traffic and air pollution. Modern mass rapid transit hits at both of them as well as at the source of the trouble.

COST OF CONSTRUCTION

THE PROPOSED RAPID TRANSIT SYSTEM for the San Francisco Bay area looks well into the future needs of the area. The first phase construction is estimated to cost $716.5 million, adequate for future needs at least through the year 1970; it includes the cost of the subaqueous tube between these cities and all of the capital costs to serve the communities within approximately 30 miles of the central core. The second phase construction will extend the system to include a loop around the southern end of the Bay and additional subcenters. This will cost an additional $112 million.

Ultimately, the system will link together all of the centers and subcenters of the area, including cross connections at the north and south ends of the Bay. The total capital costs may reach $1.5 billion spread over 35 years. Initially, this means an annual debt service of between $31 million and $33 million. This compares favorably with present expenditures on state highways in the same area of nearly $50 million annually. Freeway construction is becoming increasingly expensive as new rights-of-way become harder to obtain, not to mention the loss in productivity of land condemned for freeways or expressways, or the cost of garages in downtown areas.

The foregoing capital costs do not include rolling stock. Gross revenues are estimated to be sufficient to defray the full expense of operation and all rolling stock debt service charges with a small surplus remaining. Fares have been designed to compete with out-of-pocket costs of automobile travel for equivalent distances, taking into consideration parking fees and tolls but not depreciation, financing charges, insurance, license, registration, maintenance, etc. A zone system of fares has been recommended with collection by turnstiles, so as to minimize delay.

Capital costs of construction will have to be paid by means of a tax subsidy rather than revenue from fares. This may come as a shock to some but the alternative will be far more painful. A modern interurban transit system to serve the *entire* metropolitan area, having adequate parking facilities, fast, safe equipment, and convenient schedules, cannot be provided through reasonable fares alone. Increases in gas taxes are being felt as a result of the enormous freeway construction program involving costs of $8 million to $10 million per mile. Additional freeways, just to take care of the traffic peaks, are many times more costly than a good transit system. The motorist will benefit from transit by lower costs for freeway construction and no traffic congestion. The commuter "dead heads" will be off the road and out of the downtown garages, leaving room for those who must drive to their destinations.

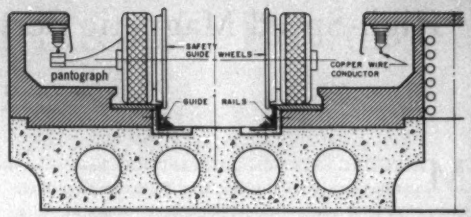


Fig. 6. Design for the application of rubber tires to supported system, showing steel guide wheel and rails.

METHODS OF FINANCING

THERE IS GENERAL AGREEMENT that rapid mass transit is the only practical solution for the Bay area, but it will take several months yet to agree on how it should be financed.

The most reasonable solution appears to be a dual source of sales and property tax. Alternate sources have been considered, including an additional gasoline tax for the area. Bridge tolls from the several toll crossings could also provide revenue besides making it possible to control the flow of commuter automobiles to a limited degree.

State and Federal sources were considered but rejected as being either too expensive to administer or too uncertain and in conflict with the basic observation that the nine counties are better able themselves to raise the necessary funds. It was noted, however, that Federal aid to highways could logically include right-of-way width for rapid transit.

The nature of the governing body to administer and construct the San Francisco Bay Area Rapid Transit System is still in doubt, but it will very likely be relatively autonomous and free from much political pressure. If the present program goes according to schedule, the first phase could be complete and operating by 1962. This allows two years to enact legislation for tax subsidy and four years for actual construction.

The success of the project depends to a great degree on the ability of the engineers to tell accurately what transit can do for the area in terms of increased property values, more business activity, and a more flexible labor supply. Convenient and efficient transportation will bring significant returns to those having to invest in it, but few will ever know the story unless the engineer takes an active part at the community level.

Of seemingly conflicting interest is the preservation of the natural beauty of San Francisco Bay and maintenance of some of the rural aspects of the area. This is possible with a modern transit system that moves people instead of vehicles, but it is a hopeless wish if we settle for more and more multilane highways with the ever increasing health hazard from air pollution. Intelligent business people want the San Francisco Bay area to grow, but these same people inwardly resent the loss of freedom and space that has become axiomatic with the horsepower age. Careful planning of the future needs of the community is a responsibility of every engineer. The things that cost us most in the long run are usually those we fail to do.

High-Speed Magnetic Servo Amplifier Measurements

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MEMBER AIEE

MAGNETIC SERVO AMPLIFIERS, based upon various forms of full-wave or half-wave push-pull circuits, have been successfully applied in the realm of instrumentation and automatic control; and they have proved to be particularly suitable for use in high-performance instrument type servos for remote positioning applications. Another possibility is the use of such amplifiers in the operation of high-speed self-balancing potentiometers.

The designer, when investigating output-input characteristics of magnetic servo amplifiers with 2-phase motor load, faces an important problem. He must consider the fact that the output current of a magnetic amplifier with rectangular-hysteresis-loop core material is, in general, highly nonsinusoidal. It represents a peculiarly truncated sine wave which consists of a fundamental (for example, 60- or 400-cycle) component and an array of harmonics having relatively large magnitudes. The separately excited 2-phase motor, however, responds only to the fundamental component of this output current multiplied by the sine of the actual phase angle between it and the substantially sinusoidal line-field current of the motor. Therefore, a conventional method for measuring this fundamental component consists in applying a single-phase wattmeter which is separately excited by means of a sinusoidal auxiliary current of fundamental frequency. This method, however, does not consider those effects on the operation of the motor which are caused by phase-angle variations in the magnetic-amplifier output circuit.

In order to make possible the correct measurement of output-input characteristics on such arrangements, the "torque-balance method" was developed. It is based upon a comparison of the actual magnetic-amplifier output voltage with a continuously adjustable sinusoidal auxiliary voltage which has fixed phase relationship with respect to the power-supply voltage, preferably corresponding to maximum-torque operating conditions. When applying the torque-balance method, the rotor shaft of the "load motor" supplied from the magnetic amplifier under test will be flexibly coupled with the rotor shaft of an identical "balancing motor" supplied from a variable transformer. Measurement of output-input characteristics can be achieved by varying the signal voltage on the input of the amplifier, and adjusting the variable transformer, i.e., the sinusoidal control voltage of the balancing motor, so that actual torque of the load motor is balanced by that of the balancing motor.

Evidently, the torque-balance method offers the possibility of determining that value of sinusoidal voltage which produces on the 2-phase motor exactly the same torque as the actual highly nonsinusoidal output of the magnetic amplifier under test. This method permits direct measurement of magnetic-amplifier output in terms of the "equivalent sinusoidal output voltage." Graphical presentation of output-input characteristics consists then in plotting the equivalent sinusoidal output voltage against signal voltage, preferably with various circuit parameters.

Another problem is that the transient-response time of modern forms of magnetic servo amplifiers is roughly one to four half-cycles of the power-supply frequency. For this reason, it is advisable to employ a transient analyzer which produces a synchronous square-wave signal voltage and permits direct visual observation of a stationary pattern on a dual-beam oscilloscope. However, application of the simple magnetic-amplifier transient analyzer[1] employing a synchronously operated mechanical switch is limited to low power-supply frequencies where a mechanical switch can be operated in a reliable way. It is, therefore, necessary to provide another arrangement which may be used equally well in the range of higher power-supply frequencies; for example, those derived from magnetic frequency multipliers.[2]

A novel form of square-wave signal-voltage transient analyzer is based upon the use of a "magnetic switch." It consists essentially of a special saturable-reactor circuit producing a synchronous unidirectional current with nearly rectangular wave shape. When applying this transient analyzer, the magnetic amplifier under test may be supplied from the 180-cycle output of a 60/180-cycle 3-phase type of magnetic frequency tripler, the input of which is supplied from the 60-cycle power supply feeding the saturable-reactor circuit acting as a magnetic switch. Operation of this circuit is based upon the fact that the actual wave shape of the alternating (load) current of an ordinary saturable reactor ("transductor") is nearly rectangular, if the control-circuit loop carrying constant direct current represents a very high impedance with regard to even-harmonic currents. In this case, these even-harmonic currents are suppressed, and the magnetic-switch circuit does operate under forced-magnetization conditions.

This magnetic-switch transient analyzer has proved to be a valuable tool for experimental studies on the dynamic properties of high-speed, single-stage, self-balancing magnetic servo amplifiers,[3] particularly those having full response to a sudden change of input-signal voltage within the time of one half cycle of the power-supply frequency.

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Potentialities of Atomic Power

W. F. LIBBY

As world population increases and deposits of coal, oil, and gas are depleted, the need for new sources of electric power becomes apparent. Suggestions are presented for bridging some of the potential gaps in our atomic energy program.

THE AMERICAN BUSINESS ECONOMY has many index markers—the Gross National Product, the number of car-loadings, the Dow-Jones stock averages together with the dollar value of "short" money, the tonnage of steel produced, and the installed electrical generating capacity in this country. These are the indexes to which we look customarily and which we add algebraically to obtain a response to the question "How is America today?"

But there is one index that transcends all others. The world's population is increasing rapidly, and we estimate that there are now about 2.5 billion people alive. This number is increasing at the rate of 20 million per year, so that by the year 2000 the world's population may be at least 4 billion. The present population of the North American continent alone is about 190 million, and the rate of increase is about 1.6 per cent per year, or 3 million people annually.

Three million new individuals are to be supplied in the United States, Canada, and Mexico with all the necessities of life—3 million people in addition to those now producing and consuming goods. This basic fact is dominant. War and pestilence notwithstanding, we cannot imagine any way in which the requirements for all kinds of materials and services will not increase because of this. More electrical power is among these requirements, for power is essential to our modern way of life.

ADDITIONAL POWER SOURCES NEEDED

ELECTRIC POWER CONSUMPTION can be correlated directly to a country's national wealth. For example, the annual per capita consumption of energy in all forms for India corresponds to 600 kwhr; the per capita income of that country is $50; the corresponding figures for the United States are 12,000 kwhr and $2,000. The quantity of installed electric generating capacity in the United States is doubling every 10 years or less. This is due not only to the normal increase in population, but also to the rise in the standard of living and the increased use of electrical appliances and electricity in general. We can expect, therefore, that by the year 2000, the electric power consumed per year will have increased by a factor of 20.

With this expansion, it is highly probable that all likely sources of hydroelectric power will have been exploited, and that the nation's capacity to produce coal, oil, and gas will have been strained to the limit. It seems certain that the United States as well as the world standard of living would, therefore, be limited by the availability of electric power, if no other source of power could be found. The present known resources of uranium on an equivalent Btu (British thermal unit) basis are more than 20 times the known resources of oil, coal, and gas combined. If controlled thermonuclear power can eventually be attained, the quantity of heavy hydrogen in ordinary water would assure us an unending supply of primary fuel.

The United States is exceedingly fortunate in that it has extremely large known deposits of oil, coal, and gas. For this reason the incentive to develop an atomic energy industry is not as great in this country as it is in European and Asian countries. In Europe, power costs are higher; coal seams have been mined rather exhaustively and, in some cases, there is actual need for "carrying coals to Newcastle." Great Britain, according to Sir John Cockcroft, needs atomic power *now* if it is to survive as a first-class power. It is one reason why the British are pushing their atomic energy program so actively; by 1975, it is hoped that atomic energy plants will be saving Britain 40 million tons of coal per year.

We conclude, therefore, that atomic power *now* is not only desirable, but also is absolutely necessary. This was the principal conclusion reached at Geneva, Switzerland, at the International Conference on the Peaceful Uses of Atomic Energy.

POTENTIAL GAPS IN THE ATOMIC PROGRAM

IF ATOMIC POWER IS A NECESSITY, the costs will have to be borne. In considering the economics of atomic power, one frequently hears the question—When will atomic power become *competitive* with conventional power? It is difficult to explain why it is not possible to give an answer naming a specific year as the target date. There are countries that today could use atomic power at a generating cost of 50 mills per kwhr; and in such countries, given the technical manpower to operate reactors, atomic power could successfully compete with present fossil fuels. In smaller installations of 5,000 kilowatt generating capacity and less, diesel-driven or other internal-combustion units generate conventional power at a cost of perhaps 8 to 10 mills per kwhr. Such power generating costs account for approximately 10 per cent of the nation's electrical bill and atomic power at 8 to 10 mills per kwhr would be "competitive power."

What is more generally understood by competitive atomic power involves the generation of electricity in large plants having capacities of 100 to 400 megawatts. We think it not unreasonable that power from central station plants can be

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expected to cost not more than 6 to 8 mills per kwhr within our lifetime, and possibly less, depending on technological developments.

In the transition from a near-monopoly by the Government to a private-industry operation with joint responsibility, one must inevitably expect some delays in the program for the rapid development of atomic power. There are rules and regulations to be drafted, agreed upon and promulgated; there are details to be explored concerning the division of responsibilities in the development of prototype reactors; there are problems in the recruiting and training of personnel; there are the problems of proportioning the cost of financing a new industry; and finally there is the question of timing.

With the captain and the captain-elect of the team now both on the playing field, even more rapid progress can be made if each points out to the other the potential gaps that are or might be developing, and suggests areas of worthwhile effort.

Among the technical factors which contribute largely to atomic power costs, the following stand out: the cost of the fissionable material consumed, the cost of fabricating fuel rods and of reprocessing partially burned fissionable material to separate the fission products and to recover unburned fuel, and the general maintenance problems in the reactor and plant itself. There are enormous opportunities for technical advancements in all three of these fields.

In the first, the cost of fissionable material itself, the principal technical opportunity may lie in further development of the breeder reactor which generates more fissionable material at the same time it produces atomic power. The breeder technology is developing rapidly, but it is somewhat too early to foretell what the real chances are of its becoming practical in the next few years. This type of reactor naturally appeals to the cost-conscious executive and because it produces more fuel than it consumes, it appears to give him something for nothing. This process of breeding may be likened to a person dropping a nickel into a soft-drink machine, getting his soft drink (energy from U-235) and six pennies in change (plutonium from U-238). This is not perpetual motion because eventually the machine (reactor) runs out of soft drinks (U-235) and pennies (U-238). With the sharing of responsibility for the development of atomic power, it becomes incumbent upon industry that it develop its own new technological concepts in reactor design.

The second potential gap concerns the area of fuel-element processing. Most of the cost data available are based on operating conditions in which the production of plutonium is maximized without regard to the generation of useful power. The design of fuel elements for power reactors poses several contradictory requirements. A fuel rod which is satisfactory from the engineering point of view is in some measure unsatisfactory from the standpoint of the chemistry of reprocessing. Corrosion stability and long burn-up in heterogeneous reactors are achieved by using cladding materials that are rather inert chemically. This increases the cost of fuel reprocessing.

There is no "best" reactor design. We are at the stage in which the automobile industry found itself in the first two decades of the twentieth century when the burning questions were: Will the Durant beat out the Star? Is the Stanley Steamer a good bet? How about Ford?

It is time now for industry to plunge into the development of satisfactory atomic-power fuel rods of its own design to maximize the over-all benefits of long-time burn-up versus the cost and the chemistry of reprocessing. Some limited experience has been obtained on actual fuel elements from power reactors. It does appear that there are opportunities for designing reactors with the thought specifically in mind of reducing this cost. Principal among the types of reactors which might have low-cost chemical processing is the family of homogeneous reactors of which the uranyl sulfate at Oak Ridge is a principal contender. It is clear that the continuous processing techniques which have proved so extremely efficient and effective in the chemical industry should be applicable to the problem in processing and removing the fission products and plutonium as they are generated from the fuel in a homogeneous reactor. There is no doubt that this can be done and there is also little doubt that it will be cheaper than the processing of heterogeneous elements.

The third line of endeavor in which industry should become active concerns the difficulties of maintenance of the reactor and the rest of the plant, particularly such problems as the corrosion of reactor containers and reactor components. Because of the intense radiation in the interior parts of reactors, chemical species are present which are extremely corrosive, and particularly in water systems, peroxides are present. The corrosion problems in homogeneous reactors are quite serious, but a solution to these problems would allow homogeneous reactors to enter the atomic power race at an early date.

A fourth line of endeavor for industry is to assist in the problem of training personnel. One of the limiting factors in the rate at which atomic power can be developed is the number of competent engineers and scientists available. These remarks are not to be taken in any way as deprecatory of the efforts of the able and devoted people now working at the task. It is just that they are too few.

When the Atomic Energy Commission (AEC) reviews proposals concerning atomic power reactors, one of the vital factors considered—and, in the minds of some of the Commissioners, the most vital factor—is the quality of the technical corps that the company or combination of companies brings to bear on the project. Difficult technical problems are not solved by mass attack; only quality, skill, and persistance will entice Mother Nature to give up her most precious secrets.

We all know, of course, that the technical corps is inadequate with respect to the enormous demands now made upon it—inadequate in numbers principally, although there are some inadequacies in training. It is a difficult thing to keep abreast of a technology advancing as rapidly as ours is today. How can one expect an engineer who was educated 15 years ago to know about atomic energy and its amazing and intricate new facets? We have a problem of adult education of our practicing engineers which is as important in many respects as the problem of educating new engineers and scientists. Our expanding economy, together with the lack of interest in the sciences and engi-

neering, has resulted in the critical shortage which has been detailed and remarked upon in many places on many occasions. We must all bear in mind that this is critical in the development of atomic power. Atomic power fares relatively well as compared to other technical fields because it is new and extremely interesting but, nevertheless, it is true that the critical factor in the rate at which we will attain atomic power involves the number and skill of gifted engineers and scientists who can attack the problem.

NEEDED—A CATALYST

On February 22, 1956, President Eisenhower announced the availability of 40,000 kilograms of U-235. This material at the current market price is worth approximately $1 billion. Half of it, 20,000 kilograms, is earmarked for domestic power reactors; the other half for foreign reactors. This allocation should be sufficient to fuel an initial electric generating capacity of several million kilowatts, depending on the types of reactors involved.

This bold step, recommended by the Commission, permits industry, both foreign and domestic, to plan sound programs for power reactors. Here is a green light that permits industry to go forward with the full backing of the United States Government and the knowledge that sufficient fissionable material will be available. Manufacturers can now negotiate with foreign countries and purchasers under an authorization issued by the AEC pursuant to Section 57.*a*.3 of the Atomic Energy Act of 1954 and discuss, on an unclassified basis, reactor designs with specific countries and specific customers. Classified discussions are permitted with Great Britain, Canada, and Belgium.

During the past year and a half, the AEC has instituted a system of access permits; it has declassified enormous quantities of literature and downgraded others; it has encouraged industry to enter into the fuel fabrication program, uranium salt production, fuel reprocessing, waste disposal, and the whole gamut of atomic energy operations, with the exception of construction of gaseous diffusion plants and the manufacture of weapons.

During this transition period from a government monopoly to private operation, is the development of atomic energy moving fast enough? Can we reduce to a minimum the inevitable delay, however slight, in the transfer process? Should some segments of American industry not now in the program be encouraged to enter the arena?

The AEC has proceeded on the assumption that private industry which has in its employ the bulk of technical talent available in this country would, if it became interested in atomic power, bring its best brains to bear on the problem. The response by private industry has been gratifying, although still small compared to the scale of Commission operations.

Private capital, at least on paper, has been pledged to the extent of a quarter of a billion dollars over the next five years to build a series of large-scale reactors under what is known as the Power Demonstration Reactor Program. It is true that most of these commitments depend upon the successful completion of certain AEC reactor experiments and prototypes, and could be withdrawn if these experiments were unsuccessful.

Despite this gratifying response from industry to date, more industrial firms should be brought into the atomic energy program. Why is it that a large segment of our industrial society has a relatively minor interest in atomic energy? There seems to be widespread feeling that atomic power is something primarily for power companies. It is also true that a large part of our leading chemical firms have not taken an active interest in the problem of atomic power as such. This statement is not meant to imply in any way that the chemical industry has not assisted the AEC in chemical activities. The processing of ore into uranium hexafluoride and uranium metal, and the reprocessing of fuel elements, are all problems in which the industry has assisted and will assist in vital ways, and some chemical companies are displaying very active interest in atomic power projects. Nevertheless, some of our larger and most efficient chemical companies are not making proposals on the atomic power program. However, if the skills possessed by their technical staffs could be made available, we would certainly attain economically competitive atomic power sooner.

Why is it that the chemical industries are relatively unknown in atomic power? It probably has to do in the main with a feeling that atomic power is not a chemical business. Perhaps it should be suggested that atomic power *is*, after all, a chemical business.

There are by-products of an atomic reactor which may be useful in the chemical industry to the point that the manufacture of power may well become a mode of entry for the chemical industry. For example, fission products are ordinarily a nuisance and have to be dealt with as waste products at the present time. We note with interest that the initial results on the sterilization of drugs and pasteurization of foodstuffs are quite encouraging and that these peaceful uses of the atom require relatively large amounts of gamma radiation. Perhaps fission products could be separated for this purpose or perhaps radiation services could be supplied from atomic power plants themselves.

It is by no means clear that fission products cannot be made useful and profitable if the talents of more chemical technologists were applied to this goal. The present costs of fractionation and handling are somewhat high, but they should be reducible by a considerable factor. Another example of the successful use of intense radiation is in the induction of chemical reactions, particularly polymerization. It may be that atomic piles will be needed by chemical plants simply in order to supply enough radiation for just this one use. Why, then, could not atomic power also be made? It would seem conceivable that a combination of a reactor which produces power and, through chemical reprocessing of the fuel, also provides irradiation sources for sterilizing food and for inducing chemical reactions might be profitable to the chemical industry and to the country as a whole.

In other words, the chemical industry might find it profitable to get into the reactor business and to think of roentgens as raw materials.

The great amount of heat which is generated from every atomic reactor cannot be used completely for the generation of electric power, and tremendous quantities of waste heat

are therefore available. It is conceivable and not at all unlikely that such large quantities of heat will be of use in chemical processing. In other words, a close look indicates that there are a number of ways in which a normal chemical business can be combined with a power generating station in ways which may be mutually profitable. We have every hope that this will be so, for we need the good chemists in the employ of industry and we need their services most urgently.

It is the feeling of many competent persons that the developments limiting the technological growth of atomic power are chemical in nature. It is not in any sense of criticism that these remarks are made, but in a sense of hope that the promise and opportunities in the field of the atom will attract this important segment of our technical community and so speed the day when competitive atomic power can become a reality.

In summary, these are some of the potential gaps that may develop in our atomic energy program and the areas in which industry can participate to minimize the effect of the transition period.

It may be added that Europe and Asia, no less than America, offer challenging opportunities in the initial development of atomic power. The "break-even" point in competitive atomic power very likely will be attained sooner in Europe and in Asia than in the United States; this situation is tailor-made for an industry which still requires some developmental work and "reduction to practice." The market for atomic power exists and should find ready acceptance.

Paradoxically, the next year or two may mark the end of a golden opportunity in the sale of reactors abroad, i.e., contracting for the *selling* of reactors, not their completion date five or more years hence. The ability to supply reactors is presently limited to only two other nations besides ourselves—the United Kingdom and the Soviet Union. With the first, our relations are cordial and only normal sales rivalry prevails. Loss of the foreign reactor market to the United Kingdon would be an economic setback to American industry, but probably not much more than this.

With the second of our competitors, the game is much more deadly—loss of the foreign market to the Soviets would be a catastrophe to the free world.

Therefore, it is imperative in this transition period from a government-operated to a privately operated atomic energy industry, that we move quickly enough *together* to assure our goal.

Research and Development Efforts in the U. S. Air Force

WILLIAM WEITZEN

The vital role the U. S. Air Force takes in the total research and development program of our nation, now faced with growing Soviet competition, is discussed. Long-range planning is necessary, as basic research begun today will generally provide knowledge in 1960, useable in design of weapon systems in 1965. As speeds approach Mach 2.0 at higher altitudes, more reliance is placed on electronics design.

DURING THE LAST FEW MONTHS, the press and radio have given considerable space and time to the problems of the U. S. Air Force budget, research and development programs, and general technical capabilities. This has been extensively publicized, against a background of the growing Union of Soviet Socialist Republics (USSR) competition and strength in the field of air weapons, by many high Government officials and military leaders.

It should be recognized that the Soviets have reached technological maturity. What many of our experts predicted they could not do, they did. Even more surprising, some of the things they were supposedly unable to do at all, they not only did, but they did in a big hurry. One devastating example proves this point—in 1946, our experts thought they could not produce an atomic bomb in less than 6 to 10 years, if at all. They did this job in about 3 years—a time period about equalled the time needed by our country to produce the first atomic bomb!

Therefore, from now on, they are a nation to be reckoned with in the technological race for qualitative superiority. This race is not in the field of aircraft only—it covers the gamut of scientific and technological endeavors, as the Soviet leaders know full well that the key to world domination lies ahead as the prize for the winner!

SHORTAGE OF ENGINEERS

RETURNING to the Air Force's position and its research and development efforts, everyone has undoubtedly heard

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time and time again of the big slice the Air Force is taking in the total national research and development program. All probably have also heard that there are not enough engineers and scientists available for a broader program. Recent data on this point has proved quite surprising.

Limited surveys made by the Air Force among representative industries, such as aircraft, power plants, electronics, etc., revealed that appreciable numbers of research and development engineers can be made available for military work from within present industrial complexes without detrimental effect on current organizations. As far as the survey showed, no Air Force contracts are being held up for lack of manpower.

However, this should not be interpreted as meaning that the Air Force feels there is no national shortage of scientific and technical talent. There definitely is a national dearth of engineers and scientists—and unless positive action is taken, it will continue on an increasingly alarming scale. The point to be understood insofar as the Air Force is concerned is that the United States has a capability of conducting a larger military research and development program. According to the National Science Foundation, there were about 650,000 engineers and 200,000 scientists in this country in 1953. The total now is probably over 900,000. Of this amount, the Air Force research and development program, on the basis of contractual dollars available, utilizes a total of about 4 per cent. Thus, large Air Force research and development changes would need only a minute percentage shift from commercial-type activities into what could be considered as more urgent endeavors.

The National Science Foundation (NSF) in a recent report[1] pays all electrical engineers, as well as the electrical industry, a very outstanding—although indirect—tribute. They analyzed research and development performed by private industry in 1953; in the electric-equipment industry, research and development costs totalled $778 millions, or slightly more than one fifth of the grand total. The aircraft industry was second with a $758-million total. In basic research, the chemical industry leads with $38 millions out of a total estimated at $150 millions—the electric-equipment industry is second with about $20 millions, for which it is to be congratulated!

The problem of increasing our national scientific potential is best left to experts, but everyone should assist in solving this pressing problem. To suggest a few critical areas—how about attacking the first and foremost problem, that of making teaching itself, especially science subjects, more attractive in many ways as a vocation at both the high school and college levels? This is essentially a community problem, but industry could participate more heavily. How about increased financial support by industry of scholarships in the sciences? How about increased salaries and opportunities for technical personnel? If the demand remains sufficiently great and the long-range future bright, more and more of our young people will make the sciences their life careers.

Lastly, why are not women utilized more effectively in the engineering programs? Of the total number of engineers and scientists in the United States today, an estimated total of less than 1 per cent of the engineers and about 5 per cent of the scientists are women. For many reasons, women do not find the sciences attractive, and frankly the fault can only lie with the men. Statistics for 1950–51, for example, show that about three men graduate for each girl—yet, in engineering, there is a 500 to 1 ratio. Something is wrong, for here is a vast untapped resource which needs considerable exploitation.

AIRCRAFT ELECTRIC EQUIPMENT

Engineering Phases now will be considered. In the days of the Wright Brothers' aircraft and for many years afterwards, the only electric equipment available in aircraft was the ignition system for the engine. During all this time, the basic concept in aircraft design was to avoid any system that was subject to failure, because flying itself was considered very dangerous.

After World War I, the aviation industry started its rapid advancement, so that many new techniques were developed. A power supply in the form of a generator and battery were added to furnish lights, air-to-ground communication, and navigational aids in the form of radio receivers. Since electric circuits were still considered unreliable, only those items not affecting the safety of flight were considered for electrical operation.

During the rapid advance of combat-type aircraft just prior to and during World War II, aircraft were equipped with more and more electric equipment, inasmuch as electricity was much better understood. Electric inertia starters and elaborate dual ignition systems, as engines grew larger, were introduced. Electrically driven motors eliminated the manual labor required for such systems as those used for retracting or extending the landing gear and flaps, or for furnishing hydraulic pressure for brakes and other equipment. Electric motors were used for driving gun turrets, boosting ammunition belts, adjusting propeller pitch, etc. The first radar was developed and used for ranging or searching the ground for targets during bombing operations. New navigational aids, instruments, and electrically driven stabilization units were developed and used. Servo loops were incorporated to control automatically such things as cowl flaps, oil coolers, turbosuperchargers, lead prediction for fire control, and bombing systems. The concept of not depending on electric systems continued though, so that no item directly affecting the safety of flight was operated by electricity unless an emergency manual system was also provided. During this period, alternating current was first introduced in common use on aircraft. Use of invertors and a-c generators for 115- and 200-volt systems was begun.

Following World War II, the advent of high-speed jet aircraft introduced additional problems. Electronics and servomechanisms really came into their own. All of the major systems were now operated electrically or partially so. Even when hydraulic or pneumatic systems were used, actuating switches, solenoids, limit cut-off switches, and other such electric gadgets were incorporated. Search, track, and ranging radars were incorporated to assist the crew during high-speed and all-weather operations. Because aircraft were traveling at high speed and high altitudes, the limit of human capability to make decisions and

react in sufficient time was rapidly reached: therefore, many of the jobs were turned over to electronics, leaving the pilot with one control to adjust, and all other parameters were controlled by electronics. Remotely actuated electric instruments became standard equipment. More sophisticated and accurate navigational aids were incorporated, requiring more and more electronics.

As the speed of aircraft approached Mach 1.0 and over, it was found that even control boosters were necessary, and that smoothing and damping circuits were required for increased stability. Automatic flight controls became a necessity instead of a pilot relief system. The limit of man's capability has now been reached to locate targets in the air and on the ground. To determine proper positioning for combat, radars are now coupled with electronic computers to solve the combat problems.

Today, complete dependency is placed upon electricity for the effective operation of military aircraft. An aircraft can no longer even rely on emergency use of batteries in case of power failure to provide sufficient electricity for safety of flight. Air-driven turbine-generator power packages have been added to the inventory of the electric-power suppliers.

In terms of power required in aircraft, the growth has been fantastic. In 1940, a *B-17* had an installed generator capacity of some 25 kw; in 1950, the *B-36*'s capacity approached 140 kw; in 1956, the *B-52*'s installed capacity neared 240 kw. This is sufficient power to service 800 average homes, and the curve still is shooting upwards.

Our power systems also are becoming far more elaborate. Constant-speed drives are required for constant frequency output—either hydraulic, mechanical, or air driven. Newer aircraft just entering service or in development have brushless a-c generators to eliminate the severe brush wear problem encountered at the higher altitudes. The tight packaging of generators in heated areas has lead to more effective cooling methods—now, oil-cooled units are entering service. Another new piece of equipment is the static rectifier—in lieu of the well-known selenium units, silicon cells are being used which have a maximum useable temperature neighboring 190 to 200 C; limits of 250 C are to be the aim in the next year or so.

Of great interest should be the fact that nickel-cadmium and silver-zinc alkaline batteries are being extensively service-tested. As you know, nickel-cadmium units have 20 to 30 times the life of commercial lead acid units, while the silver-zinc batteries have about $3^1/_2$ times the capacity.

Indicative, too, of the present state of the art in electric equipment are the present tight limits imposed on the generation or regulation of power during steady-state operation; today, these limits are: $\pm$ 1/4 per cent for frequency, $\pm$ 4 per cent for harmonic content, and $\pm$ $2^1/_2$ per cent for voltage.

Most of the present electric equipment in operational aircraft today is adequate for the environment it encounters. However, as operating speeds approach Mach 2.0 and flights are higher and higher, the Air Force meets increasingly difficult problems. The demands being placed on engineers and the electrical industry are steadily growing, and there seems to be no end in sight.

FUTURE AIRCRAFT PROBLEMS

WHAT ARE SOME OF THE SYSTEMS and problems to be faced in the future? At supersonic speeds, there must be more and more reliance on fully automatic flight systems. The newest aircraft are being designed with electronic eyes and brains. The crew will be furnished only with a situation display and a decision selector.

There is need for complex electronic equipment to program flights from take-off, to search, to intercept or bomb, to return, and to landing—all this under any conceivable weather conditions.

The environmental requirements being imposed on all electric equipment are growing in severity. Today, temperature is the most critical factor in the operation of our equipment. In a few of our most advanced operational aircraft, it is necessary to derate present-day equipment in order to operate it.

One of the Air Force's most pressing technical problem is to make all electric equipment capable of sustained and reliable operation under an environmental temperature condition of 250 C. Anyone in industry can appreciate what this means, and it is from industry that the Air Force hopes to get its answers.

Looking ahead what else do we see? There is a need and a current search for ways and means of reducing starting (or inrush) currents in electric motors by methods or designs presently unknown.

Engineers have just scratched the surface of real high-speed flight and the popular "thermal barrier." In 1960, for example, there must be equipment capable of reliable operation under temperatures neighboring 750 F. Installed power requirements for the larger aircraft should then approximate 300 kw. In 1965, this temperature limit should be raised to 1,200 F as a goal, and generating capacity should reach 500 kw.

Everyone is aware of the Air Force's aircraft nuclear propulsion program to obtain an atomic-powered capability. This presents another problem in that all equipment and materials must be nuclear-radiation resistant to a greater or lesser degree.

With respect to regulations and the percentages mentioned previously—in 1965, certain limits are looked forward to as: $\pm$ 1/4 per cent for frequency, $\pm$ 1 per cent for harmonic content, and $\pm$ 1 per cent for voltage.

Some people may feel that the temperature goals are unrealistic—that it should be simpler to cool and air condition the electric equipment; however, this is not true! As aircraft operate at higher and higher Mach numbers, the air temperature rise goes up exponentially, so that there is the situation of running out of a heat sink into which waste heat can be poured. If it is necessary to install air-conditioning equipment, the aircraft suffer increasingly greater performance degradation because of the weight, size, and complexity of these cooling systems. If at all possible, such crutches must be avoided.

There is a new important concept the Air Force is adopting in order to reach these goals and to make the situation much easier.

Practically all the research and development money in

electricity is now devoted to advancing the state of the art in this broad area. The Air Force is endeavoring to support the electric-equipment industry by increasing its fundamental knowledge. Our old established concept of developing specific hardware for inventory use is being changed—hardware development is being relinquished, per se. This allows the airframe people to prepare the detailed specifications for the equipment needed for specific weapon systems and submit these requirements to the manufacturers who—fortified by new knowledge gained under the auspices of Air Force research and development—will design and build advanced equipment to meet the needs. The Air Force will continue to co-ordinate designs and standards so that the ends of standardization and logistics support can be met. It is expected that industry will appreciate this problem and willingly comply with mutually established standards.

What are some of the ingredients of an effective research and development program as the Air Force sees it? It is essential in this research and development business to continually indulge in long-range research and development planning—by long-range is meant anywhere from 5 to 15 years hence. Such planning should include: facilities planning; personnel plans for acquisition, training, growth, and utilization; fiscal plans and requirements; technical estimates or market analyses; and, perhaps, technical evaluation of growth potential in allied and competitive lines.

The entire problem can best be summarized by recognizing that more time and money must be spent on basic research and development, as the "well of knowledge" in this area is simply running dry. Again, the time element should be emphasized in planning—basic research and technical developments begun today will generally provide knowledge in 1960 that can be used to design hardware for weapon systems which may fly in 1965. There is no easy shortcut.

RELIABILITY

ELECTRONIC and electric equipment cannot be discussed without mentioning the subject of "reliability." Reliability has become and will remain a primary consideration in this equipment, inasmuch as everyone now is becoming totally reliant upon the many electrons running around in modern high-performance weapon systems.

A recent study by Rand Corporation showed that the cost of electronic maintenance in the Air Force is twice as much as the original cost of the equipment installed each year. The U. S. Navy says the cost of electronic equipment maintenance is 10 times its original cost, assuming a life span of 5 years. The cost to the taxpayers is heavy and continual.

There are also other economic considerations. It costs approximately $500 per hour to fly common-type military aircraft. Much of this flying time is wasted if electronic equipment fails—many mission aborts result from such failures. Another sizable economic penalty is paid because, to accomplish a specific military plan, enough aircraft must be programmed and procured to do the job, with an allowance being made for those aircraft which statistics indicate will abort their missions.

The military departments have been actively engaged in efforts to improve reliability for some time. Industry has also joined forces to improve the quality of these products. This teamwork, i.e., industry working with the military departments, has had gratifying results. Definite improvement can be recognized and this change is continuing. Many companies have played discrete and important roles in this program.

One step taken by the Department of Defense to assist Government–industry teamwork in this respect was the establishment several years ago of the Advisory Group for Reliability of Electronic Equipment (AGREE) Committee. This committee, made up of electronics engineers and executives from factories and from the military departments, with headquarters in the Department of Defense, has spearheaded the attack on unreliability. The committee collects facts data, recommends standards, recommends procedures, and serves as a focal point and common ground for bringing together new applications, advances, improvements, and techniques. One important contribution has been the preparation of a bibliography listing the most up-to-date authoritative technical papers in existence today for design engineers. The papers give specifics on how reliability may be achieved.

THE FUTURE

THE PROBLEMS faced by the United States in meeting the demands of the future—both in national defense and in maintaining the highest standards of living in the world—can only be resolved with the co-operation and assistance of engineers, as individuals; industry as a unit, under the American way of life; and technical societies like the AIEE. Therefore, for that which has been contributed to the Air Force and to the national good, and for that which each person will contribute in the future, the Air Force thanks you.

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1. Science and Engineering in American Industry (pamphlet), National Science Foundation, Washington, D. C., 1954.

Heavy Stator Shipped

Heaviest peacetime shipment of a single item in the history of the Port of New York was loaded aboard the 10,290—deadweight ton Kyoei Maru at the New York Navy Yard, Brooklyn, N.Y., recently. The item is a 185-ton generator stator—a portion of a 125,000-kw steam turbine-generator unit, which will be installed at the Tokyo Electric Power Company's Chiba electric-power generating station in Japan.

The powermaker was manufactured by General Electric Company's large steam turbine-generator department plant in Schenectady, N.Y., and will be capable of satisfying the average yearly electrical needs of nearly 925,000 Japanese. It is also the most powerful electric generating machine ever to be exported from the United States.

Shipboard Use of 400-Cycle Electric Power

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SINCE 1932, 60-cycle a-c systems have been used in most naval ship's service electrical installations, particularly installations of large capacity. These systems operated satisfactorily and served well during World War II. However, during and since that period the trend has been to increase the use of electric power, thereby increasing weight and space requirements of the electric plant out of proportion to the size of the ship, and to require improved performance of the equipment installed. In order to solve this problem, consideration must be given to the basic factors influencing electric equipment designs. For example, an increase in system frequency increases maximum speed of rotation, thereby decreasing the weight of rotating electric machinery. In addition, high-frequency transformers and reactors require a lower value of maximum flux and, hence, a smaller iron core than corresponding 60-cycle units. Inherently smaller time constants permit increased speed of response, an advantage in certain control systems.

There are other factors to consider which partially offset these advantages. Inherent characteristics of small, lightweight, high-frequency equipment require that special consideration be given to noise reduction, higher operating temperatures, and mechanical problems that arise with the higher rotational speeds and smaller air gaps. The smaller hea dissipation surface requires that more consideration be given to ventilation and equipment protective features to prevent burnout. Also, the advantages offered by the use of a higher frequency in marine applications have to be great enough to compensate for the high costs associated with the development, design, and manufacture of electric equipment for a 400-cycle frequency.

Realiz ng the advances that could be achieved by a complete investigation of such items as increased frequency, the Navy decided to build an advanced design destroyer in which the maximum number of new design components and systems would be incorporated. This ship is the *U.S.S. Timmerman*, formerly the *DD828*, and now the *EAG152*. In an effort to achieve the maximum benefit, an increase in voltage and frequency were considered worthy of consideration.

Leading manufacturers of generators, switchgears, transformers, motors, control equipment, and auxiliaries were called upon to design, develop, and furnish equipment which would meet the requirements of the basic concept. As a result of these studies, a 1,000-volt, 400-cycle electric plant was selected for the *U.S.S. Timmerman* on the basis of estimated data furnished the design agent. The estimated data was submitted largely on the basis of original new design, because comparatively little manufacturing experience was available on higher voltage and frequency equipment of the sizes and applications required.

The use of this electric plant on the *U.S.S. Timmerman* instead of a 450-volt, 60-cycle plant resulted in a weight reduction of approximately 31 per cent. Approximately 15 per cent of this saving is attributable to modern design, 5 per cent to the increase from 450 to 1,000 volts, and the remaining 10 per cent to the increase in frequency.

During the 3-year period since completion of the *U.S.S. Timmerman*, numerous operating problems have occurred, such as casualties to the turbogenerators. However, subsequent modifications to these units have resulted in satisfactory performance. In addition, the 950-volt, 400-cycle motors are smaller, have less thermal capacity and operate at higher speeds and temperatures than normally encountered. It is not surprising, therefore, that numerous bearing and winding failures have occurred. Some improvement in motor performance has resulted from a careful maintenance program, but a satisfactory solution will require modification to motor designs.

Even though the *U.S.S. Timmerman* trial program is still in the early stages and underway operations have been limited, many technical achievements have already been realized. Valuable information from shipboard operating experience and tests has already been incorporated in the design of 400-cycle turbogenerators for limited applications in new ships under construction. The new carriers, for example, have a 1,000-volt, 400-cycle system for aircraft starting and servicing. Additional operating experience on the electrical equipment is still needed in order to obtain information as to life, amount of maintenance required, dielectric properties, and conditions of bearings and insulation resulting from continuous service.

Over the past years, shipboard electrical installations have grown from simple low voltage (120–130) d-c systems to large complex systems. During this growth, we have gone, in most cases, from the d-c systems to 450-volt, 60-cycle a-c systems. There is no reason to expect that the shipboard electrical installations will not continue to grow, with further demands for still better performance and more output with less space and weight. It is expected that a continuing increase in the use of 400-cycle power will not be accomplished by a complete change in the basic electric plant at one time as was the case in the change from d-c to a-c, but by a gradual change with an increasing portion of the plant made up of 400-cycle applications.

This increase will probably be more rapid in the field of electronics and control circuits than in other fields. However, we probably will see 400-cycle fluorescent lighting installations in the not too distant future. In the power drive field, it is expected that increasing use will be made of 400 cycles where increased speeds are desired to obtain better characteristics on the part of driven auxiliaries.

Digest of paper 56-184, recommended by the AIEE Committee on Marine Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Applications and Industry*, 1956.

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New Control Installations in Transmission Stations

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THE ELECTRICITY SUPPLY BOARD (ESB), Ireland, as a portion of its postwar expansion program, constructed a series of 110/38-kv transmission stations in the period 1948–52. So far as possible, the stations were built to a common basic plan. However, they were not identical but varied in power-transformer ratings, complexity of control, and number of high-voltage outlets. Accordingly, their cost varied from roughly $14 to $20 per kva of installed transformer capacity. The control installations averaged 16 per cent of gross station cost.

In 1953, when the planning of another series of transmission stations was undertaken it was felt that the preceding design of control installations had been unduly expensive. To determine where savings could be obtained most effectively, an analysis of control cabling was made. This analysis indicated that control-cable expenditure in the projected new stations could be reduced to one fifth that of corresponding previous stations by adoption of the following measures: (1) For control cables proper, using adequate but minimum copper section and utilizing suitable plastic insulations and sheathings; (2) Introducing telephone-type cable for the 24-volt direct current signaling circuits; (3) Removing the protective relays from the control room and repositioning them at their high-voltage cubicles; (4) Applying common instrumentation, i.e., employing one set of instruments to serve a number of similar high-voltage circuits, measurements being taken by switching the set of instruments into these circuits in turn as desired; and (5) Installing only single-element indicating instruments on switchboard.

The implementation of these measures constitutes a new design of control installations, which not only saves 80 per cent in the cost of cabling, but also achieves even more significant economies in control buildings, control equipment, and pertinent labor.

The new design is being applied to five unattended transmission stations under construction at present, each of which in its ultimate development will cater for: four 110-kv lines, eight 38-kv lines, and two 110/38-kv transformers.

Some of the main points of difference between the previous and new designs in relation to existing and new stations of approximate similarity in high-voltage layout and magnitude, are: (1) The floor area of the control room is reduced from 120 square meters in the existing stations to 20.25 square meters in the new stations; (2) The cable room in existing stations, which is immediately beneath the control room and of identical floor area, is replaced in the new stations by a trench behind the panels; (3) The control room in existing stations has 37 panels each with double wings to carry ancillaries and wiring (The new control-room has seven wingless panels; the walls behind the panels are utilized to carry assemblies of ancillaries, which are arranged in definite physical relationship with the circuits they govern on the panels); and (4) In existing stations, each high-voltage circuit is equipped with a set of conventional indicating instruments of various types as required. But in the new stations, only two sets of instruments (ammeter, megawattmeter, megavarmeter, and voltmeter) are provided, one for 110-kv lines and the other for 38-kv lines and the 38-kv side of the power transformers. The current coils are 1-ampere rated and are supplied from an auxiliary 5-to-1 current transformer in each high-voltage cubicle. The power instruments are single-element and, hence, are accurate only on balanced circuits, but in view of the normal characteristics of the ESB transmission systems, it is considered that these instruments have precision adequate for their purpose and that such errors as may occur will be tolerable. Readings are obtained by manipulating the appropriate selector key, thus operating a contactor in the particular cubicle and lighting an identification lamp in the mimic diagram to designate the circuit being measured.

Fig. 1 is a workshop photograph of the assembled panels and operator's desk for one of the new control rooms.

In comparison with the previous arrangements in existing stations, the new design of control installations promises savings of the order of $50,000 per station.

Fig. 1. Panel assembly and desk prior to dispatch to site

Digest of paper 56-7, "New Design of Control Installations in Transmission Stations," recommended by the AIEE Committee on Substations and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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Live Flying-Spot Color Scanner

J. H. HAINES G. R. TINGLEY

This new color-television system, the Vitascan, an all-electronic version of the old-style mechanical type, is the simplest and most reliable live-action color system now in existence. It can be regarded as using the reverse of conventional studio methods, as the flying-spot tube is substituted for the image-orthicon camera tube and clusters of phototubes replace regular studio lighting equipment.

COLOR-TELEVISION PICTURES of high quality without the use of expensive and complicated color-television cameras or highly trained and skilled camera and maintenance crews are now produced by the "Vitascan" system, as developed by the Allen B. Du Mont Laboratories, Passaic, N. J. It is, in fact, a modern all-electronic version of the earliest forms of mechanical live television pickup which employed the flying-spot scanning principles.

Although Vitascan cannot displace storage-type color-television cameras, it is expected that its unique advantages will earn it a modest place in color-television programming. This article proposes to explain its virues and shortcomings.

On an historical level, it is interesting to note how the present technical state of the art has allowed this revitalization of the old flying-spot principle. Thus, basic principles are discussed, and evolution of a workable system leading to present commercially available equipment is traced.

HISTORICAL REVIEW

THE ANALYSIS AND SYNTHESIS of a subject by television was first achieved by J. L. Baird, in England, in 1923. He employed a 30-line mechanical scanning system. As late as 1937, the British Broadcasting Company (BBC) in London, England, programmed with a Baird mechanical live-pickup flying-spot scanner operating at 240 lines.

In advancing from 30 to 240 lines, the mechanical scanner system was doomed for two major reasons. First, the extremely acute mechanical problems and, second, the lack of sensitivity of the then available photocells. Since multiplier photocells were not available, the low signal level gave excessive noise when amplified, thus limiting the action to head and shoulder close-ups.

The first nonmechanical live pickup, using a cathode-ray tube, was demonstrated early in 1947 during the first Federal Communications Commission's (FCC) color hearings in connection with the Radio Coporation of America (RCA) simultaneous color-television system.[1] The 18- × 24-inch scanned area limited the device to head and shoulder pickups.[2] Although *931A* multiplier phototubes were used, the light collection was severely restricted by the 5/16- × 15/16-inch pickup area.

The Du Mont color-scanner development program, which began in 1949, took advantage of the newly available 2-inch multiplier phototubes. Although the transmission of slides, film, and opaques was achieved with considerable success, it was not until 1954 that components and techniques had sufficiently improved to allow the contemplation of a satisfactory color scanner for limited live pickup work, which would surmount some of the shortcomings of earlier equipments. The real technical breakthrough came with the commercial availability of the first 5-inch multiplier phototubes, the Du Mont type *6364*.

At first, efforts were directed toward providing a live-action color pickup of a $7^1/_2$- × 10-foot scanned area solely as a signal source for research purposes. However, notwithstanding its inherent limitations, it became apparent that a very definite use could be made of the principle in normal color-broadcasting operations. A commercial version of this device, the Vitascan, was designed and a prototype was demonstrated publicly for the first time at the National Association of Radio and Television Broadcasters (NARTB) Convention in May 1955. This article is not intended as a detailed description of the present commercially available equipment, but rather as a history of its parentage.

BASIC PRINCIPLE OF OPERATION

THE LIGHT from a high-voltage high-beam current flying-spot scanning tube, which emanates from the unmodulated rectangular scanning pattern, is focused onto the subject or scene being televised through a suitable lens system.

As this light spot traverses the scene in its regular pattern, it is reflected from the various objects; the amount and color of reflected light at any given moment varies with the reflection factor and color characteristics of that part of the scene. The scanning light incident on the scene is therefore modified or modulated by the different reflective characteristics of the scene from one part to another. These variations in intensity and color of the reflected light are picked up by groups of multiplier photocells, suitably disposed around the scene, which linearly convert the light energy to varying currents for processing through the normal color-video apparatus for flying-spot scanners.

The phototubes are covered with suitable color filters which, in combination with the spectral emission characteristic of the scanning tube and the response of the phototubes, determine the spectral characteristics of the system.

The major differences between the flying-spot scanning

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operation for the transmission of live pickup and that for transparencies are: (1) the scanned area is many thousand times larger for live pickup than for slide or film operation; (2) the scanning light is reflected from solid objects rather than transmitted through flat material as in the case of a transparency; (3) using a multiplicity of phototubes, lighting effects similar to other live-action television systems are provided; (4) controlled illumination, in addition to the light from the flying-spot, must be provided in the studio; and (5) special television previewing techniques must be employed.

In visualizing how the Vitascan live-action scanner operates, it is helpful to regard the system as being the reverse of conventional studio television operation. Clusters of phototubes replace the studio lighting fixtures and the flying-spot tube is substituted for the image-orthicon camera tube.

Normally, light from the studio fixtures illuminates the scene, and reflected light is gathered by an objective lens onto a light-sensitive electrode, where it is transformed by the scanning process within the camera tube into electric currents. In contrast, the scanning tube and its lens, placed where the camera would normally be, produce the light and perform the scanning operation at the same time. Some of this light reflected from the scene is intercepted by the phototube clusters and converted into electric currents.

The analogous relationship described in the foregoing was recognized by the early pioneers in television; this relationship was described by Lance and Percy in 1935[2]: "In this studio there has been a great deal of work done to produce an artistic effect by correct lighting of the artists; in fact, it was found that, since each photocell could be controlled separately to give the correct balance between top, side, and back lighting, in imitation of the lighting of a floodlight studio, the simplest way of working out the lighting effects was to regard the scanning projector as a camera, and the photocells as light sources, placing them and altering their gain from that point of view."

STUDIO REQUIREMENTS

Inasmuch as the Vitascan system operates by virtue of a scanning light beam, no illumination other than that from the controlled scanning source can be allowed to reach the phototubes during the scanning period because this extraneous light will only produce noise.

The studio, therefore, must be sealed against ambient light. Eliminating all ambient light, however, would leave the studio in relative darkness because the light from the scanner is insufficient to illuminate the studio adequately.

This acute problem was literally a stumbling block in earlier versions of live scanner operation, since lack of light seriously restricted the movement of performers about the studio, made it impossible to read, and produced a staring expression on the faces of the actors.

The difficulty of providing adequate light in the studio without interfering with the Vitascan operation has been resolved by utilizing the 60-cycle vertical-blanking period, during which time the scanning beam is extinguished.

During this blanking period, pulsed or stroboscopic lights synchronized with the television system are flashed on in the studio, providing adequate illumination for studio action without upsetting the scanning operation. During this same period that the lights are pulsed on, the phototubes or associated video amplifiers, or both, are keyed off to prevent overloading. In addition to being lighttight, noise is further reduced by employing reflective materials on the unscanned walls and ceiling, thus increasing the light directed to the phototubes and additionally softening the shadows.

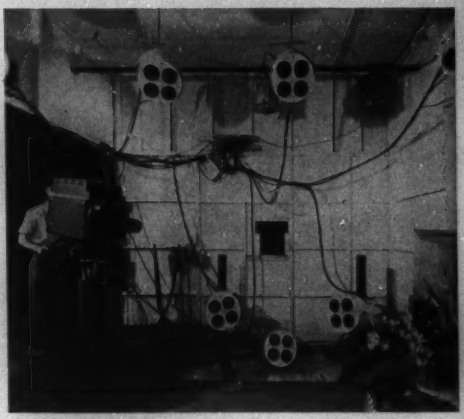

Fig. 1. Television studio, showing Vitascan and phototube clusters.

EQUIPMENT COMPLEMENT

In its present form, the Vitascan is operated as a one or two "camera" system. The "cameras" which, in actuality, are flying-spot scanners, may be fixed or mobile. One favorable arrangement, which was used at the initial public demonstration at the 1955 NARTB Convention, includes the Du Mont multiscanner equipment to provide a fixed scanner, augmented by a mobile scanner packaged to resemble a standard image-orthicon camera.

Fig. 1 shows the studio of 200 square feet at the NARTB Convention. The equipment complement included the following items: (1) two scanning light sources, one mobile and one fixed unit, utilizing the Du Mont multiscanner; (2) seven clusters of Du Mont 5-inch multiplier phototubes; (3) six pulsed light fixtures; and (4) processing amplifiers.

The Du Mont multiscanner, as seen in Fig. 2, is a flying-spot scanner system for slide, opaque, and motion-picture film pickup. It utilizes a 7-inch high-voltage cathode-ray tube operating at 40 kv. The tube, which is aluminized, employes a short persistence zinc-oxide phosphor, coated onto a high-quality nonbrowning neutral-density face plate. Use of this gray face plate, rather than a clear face plate, improves the small area contrast by a factor of ten by the reduction of halation flare. Fig. 3 shows how the multiscanner is easily adapted to live pickup work by the removal of the cabinet for 4- × 5-inch opaques and the addi-

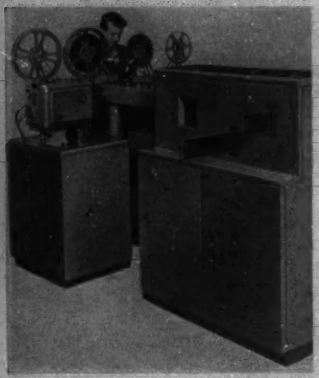

Fig. 2. Multiscanner.

tion of the desired focal-length lens to the flying-spot cabinet.

The mobile light source (Fig. 4) resembles a television camera and includes a lens turret to provide a choice of focal lengths for close-up, medium, or long-shot work. This mobile scanner employs a 5-inch high-voltage cathode-ray tube, operating at 35 kv, in which special precautions have been taken to minimize the phosphor grain size by careful control of the screening process.

The phototube clusters consist of four Du Mont 5-inch diameter 10-stage multiplier phototubes of the type shown in Fig. 5, closely spaced in a compact housing (Fig. 6). Each phototube is covered with an appropriate color filter to analyze the reflected light from the scene into three primary color channels. One cell is allocated to the green (*G*) channel, and one to the blue (*B*) channel. Two cells are supplied for the red (*R*) channel in order to compensate for the lack of sensitivity at the red end of the spectrum. The phototubes identified with each color channel are bridged onto a coaxial line which is terminated at each end, thus allowing the addition of as many clusters as desired.

The pulsed, or stroboscopic, lights are of two types.

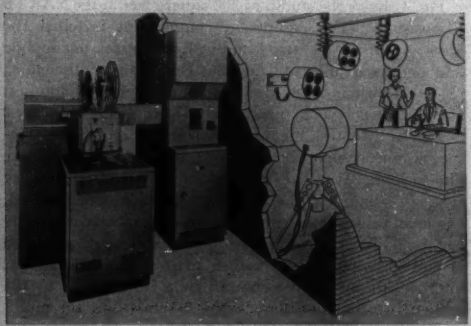

Fig. 3. Multiscanner used as fixed Vitascan.

In one version, small commercially available xenon flash lamps are used, five to a reflective fixture. These lamps are triggered to flash during the vertical-scan blanking interval. In the second developmental version, miniature cathode-ray tubes are employed, three to a reflective fixture. These tubes are operated at 15 kv and are pulsed ON during the vertical blanking interval.

Operation on the *R*, *B*, and *G* signals, developed from the combined outputs of the phototube clusters, is accomplished in conventional video processing amplifiers, providing phosphor correction, gamma correction, and blanking insertion, as normally used in flying-spot scanners.

The foregoing paragraphs have presented a brief general look at the Vitascan system. An expanded explanation of some of the more novel features of the system follows.

VITASCAN PHOTOMETRY

RETURNING to the basic principles of the Vitascan, it is helpful to give a definition of a live-action flying-spot scanner. A live scanner is one which televises an object having depth, and which, consequently, must provide the appearance of "effects lighting." Fig. 7 depicts a schematic top view of a simple monochrome Vitascan. The scene being televised is a square white card suspended some distance from a gray background. When a single phototube pickup is placed at the right of the scanner, the television picture produced looks like one from a storage-type television camera viewing, from the cathode-ray tube position, the scene lit by a single lamp at the phototube position.

Consider what happens at seven equal increments of time, *T1* through *T7*, when the scan is just beginning a new line in the middle of the picture. The tiny spot on the cathode-ray tube is imaged by the objective lens onto the left-hand side of the gray background. A small portion of the light is picked up by the phototube and a signal corresponding to gray is generated and displayed on the screen of the television monitor. Between *T2* and *T3*, no signal is produced by the phototube, which results in a black shadow on the monitor. At *T3* and continuing through *T5*, the phototube transmits a white signal. Finally, from *T5* to *T7*, a gray signal is again displayed.

If only a single phototube is employed, the resultant picture appears to be illuminated by a light at the phototube position. By employing a number of phototubes, any desired lighting effect can be produced such as "key," "fill," and "back" lighting. The apparent intensity of these "lights" are controlled simply by the photomultiplier gain. Thus, the video level and the lighting effects are controlled by only one individual.

With the color Vitascan, the picture is analogous to having red, blue, and green lamps illuminating the scene rather than a single white lamp.

What additional problems are raised when the fixed Vitascan is replaced by a mobile scanner which can be moved around the studio and which employs a turret with a variety of objective lens focal lengths? For instance, if the scanner is dollied very close to the subject, it might be supposed that the signal level would be greatly increased. This supposition is incorrect. If a 6- × 8-foot gray area

is scanned, a corresponding gray signal amplitude is produced. If now the scanner dollies in to scan a 3- × 4-foot area, the signal level will remain exactly the same, because the phototube remains at the same distance and still collects the same proportion of the same total light flux leaving the scanner. Also, the small area will be four times as bright as the large area but, since it has only one fourth the area, the total light picked up will be constant.

The same flexibility of movement is allowed, as with any television camera, when the lens turret is changed from narrow to wide lens. In any scene, as long as the effective *f*/numbers of the lenses are the same, the signal level will not vary with focal length.

The color Vitascan also produces a live-action signal source totally devoid of color registration errors for testing of color-television equipment. This absence of color misregistery is readily appreciated by reference again to Fig. 7. Just prior to *T5*, the *R*, *B*, and *G* signals are equal and produce white. When the spot moves to the gray background, all the phototube outputs must change together. There is no way for one color channel to change at a time different from another.

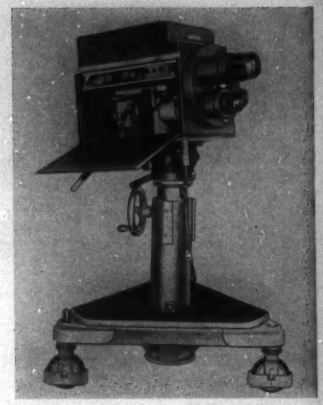

Fig. 4. Mobile light source.

SPECTRAL CHARACTERISTICS

When the Vitascan is used for monochrome television pickup, the over-all spectral characteristic is determined by the product of the phosphor times the phototube spectral responses. This resultant curve is shown in Fig. 8. If appropriate color filters are placed before the phototubes, the resultant *R*, *B*, and *G* sensitivities are shown. Sensitivities relative to monochrome give *R*, 1 per cent; *B*, 17 per cent; and G, 50 per cent. Thus, the red output was doubled to 2 per cent by employing two red phototubes for each blue and green one. To obtain equal *R*, *B*, and *G* signals for white balance, it is necessary to adjust the photomultiplier gains suitably. The spectral characteristics for equal-signal white, with the corresponding gains indicated, are shown in Fig. 9. The poor red sensitivity, requiring increased red photomultiplier gain, results in the red channel noise determining the over-all acceptability of the signal-to-noise ratio in the simultaneous color signal.

With the storage-type color-television cameras, color contamination is present because of the nonlinear transfer characteristic of each camera tube. From the standpoint of color fidelity, the Vitascan is preferred to a slide scanner as a color signal source, because colorimetric failures of the film processes are avoided.

OPTICAL PARAMETERS

Signal-to-noise and depth-of-field considerations have proved to be serious problems. Although theoretically quite independent, the economics of equipment design makes them mutually antagonistic.

In the first experiments, the depth-of-field was only about two feet. To increase the depth-of-field, the lens was stopped down, making the signal-to-noise ratio objectionable. To improve the depth-of-field, it is necessary to use a smaller lens aperture, or smaller scan size, or both. In either case, the amount of light incident on the scene is decreased. Unless the same total amount of light is collected by the phototubes, the signal-to-noise will suffer. Higher collection efficiency can be accomplished by adding simple reflectors to each phototube cluster and by covering the walls with aluminum sheeting. Also, the total of phototube clusters can be increased; this gives interesting modelling effects in the lighting as well as greater light collection.

As a considerable economic problem would exist in larger studios employing mobile cameras, it was necessary to consider the depth-of-field problem purely from the standpoint of the camera design itself. First, a general analysis of depth-of-field as a function of cathode-ray tube raster size and other variables was made. Second, the final optimizing of the camera design for signal-to-noise was determined by practical problems of cathode-ray tube operation.

The present Vitascan units operate at a distinct theoretical disadvantage when compared to image-orthicon cameras in regard to depth-of-field but, in reality, this

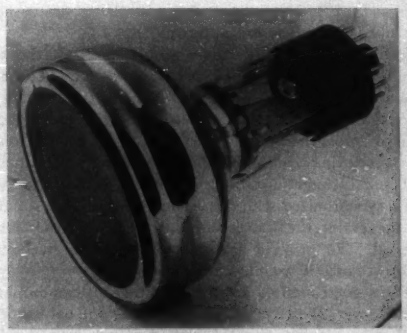

Fig. 5. Multiplier phototube.

Fig. 6. Phototube cluster.

difference is less than that indicated by the figures since the theoretical depth-of-field advantage is far from being attained in image-orthicon color cameras because of certain effects which reduce the sharpness. This lack of cripsness is caused, first, by optical aberrations introduced by the complicated lens relay system and, second, by misregistery of the red, blue, and green camera scans.

The depth-of-field seriously limits the television programming applications, so that a compromise had to be made in the mobile Vitascan design. A 5-inch cathode-ray tube allows a 3.0- × 4.0-inch scan size or smaller. Experiments indicate the smallest practical scan size to be 2.1- × 2.8-inch, determined primarily by the current saturation, grain size, and life of the phosphor. Typical operating conditions are 35-kv accelerating voltage at 250-microampere beam current. The depth-of-field of the 2.1- × 2.8-inch raster at $f/2.8$ is adequate for many types of television programming; at 10-foot focus, nearly a 4-foot depth-of-field is realized.

STUDIO STROBE LIGHTING

As previously pointed out, two different methods of lighting during the vertical blanking interval have been developed. At present, the first production version of the Vitascan uses a xenon flash lamp, pending quantity manufacture of another light source, a miniature short-persistence cathode-ray tube. Although there are points for and against both methods, the scheme utilizing the cathode-ray tube is ultimately to be preferred.

In the first method, a trigger voltage of several thousand volts is applied to the external electrode of a U-shaped xenon Amglo type *U-35K* lamp. This voltage ionizes the gas and a d-c potential of 350 volts from a charged capacitor applied across the internal electrodes maintains the ionization, producing a blue-white light output for approximately a 100-microsecond duration. Inasmuch as the trigger voltage is synchronized with the vertical drive from a standard sync generator, the flash occcurs during the vertical blanking interval. To provide a suitable light level, five xenon lamps are used in each fixture (Fig. 10).

The second method for strobe lighting utilizes miniature cathode-ray tubes, Du Mont type *K1388*, as light sources. Each tube consists of a $1^1/_2$-inch diameter glass envelope with a special triode gun at one end and a metal phosphor plate, inclined at 45°, welded to the other end. This enables the phosphor to be efficiently air-cooled. The special gun is designed to produce an unfocused flood of electrons over the phosphor surface, typical operating figures being 15-kv accelerating voltage at 200-microamperes average current (Fig. 11). An experimental light fixture utilizes three of these tubes (Fig. 12).

With either of the aforementioned methods, a high-current pulse is generated at the output of the phototubes during the strobe lighting period. It is, of course, essential to prevent this pulse from appearing in the video signal leaving the processing amplifier. There are two convenient ways to accomplish this: first, by keying the phototubes off so as to make them inoperative during the vertical blanking interval; and, second, by clipping and keying out the unwanted pulse in the video processing amplifier.

PREVIEW FACILITIES

The problem of providing preview facilities, where more than one scanner televises the same scene, requires consideration. Suppose that two Vitascan cameras are scanning the same scene from different positions. Because both light sources would be operating at the same time, a mixed signal is generated by the phototubes. On the picture monitor, this would appear as two superimposed images as seen from the respective camera positions. The problem, therefore, is to derive two separate signals, without crosstalk, from the two scanning light sources. Obviously, some multiplexing system must be employed.

There are several possible ways of providing a preview picture for the Vitascan; suggested methods were judged for suitability by the following criteria: (1) economy, governed by the amount of additional nonstandard equipment required; (2) quality of picture, that is, signal-to-noise ratio, resolution, color, or black and white rendition; and (3) complexity of operation. Previewing systems group themselves in two main categories, time and spectral multiplexing. As an example of time multiplexing, the retrace portion of the horizontal scanning cycle for the preview could be utilized. Spectral multiplexing systems can be operated within or outside of the visible spectrum.

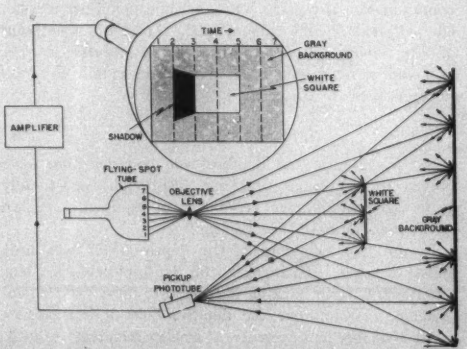

Fig. 7. Principle of Vitascan "lighting."

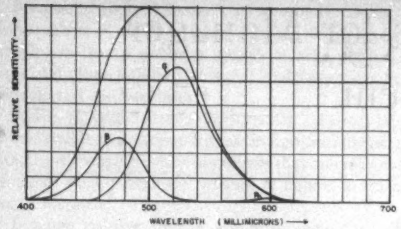

Fig. 8. Color Vitascan filter shaping.

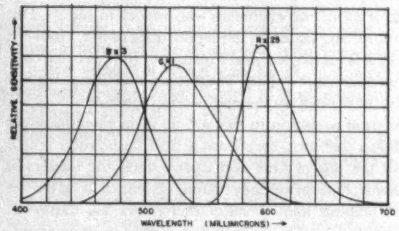

Fig. 9. Color Vitascan spectral characteristic.

The preview may utilize the existing phototubes or an auxiliary-storage camera associated with the scanning source. A number of other methods have been investigated and discarded; however, others hold considerable promise of ultimate success.

CONCLUSIONS

THERE APPEAR TO BE three major fields wherein the Vitascan should find application. These are: (1) industry, (2) color-television research, and (3) color-television broadcasting.

Experience with the color Vitascan leads to enthusiasm concerning its place as a research tool. It has definite advantages over a transparency scanner. It provides excellent color-television signals, especially in respect to resolution, color rendition, and lack-of-color misregistery. From an operational standpoint, it is the simplest and most reliable live-action color-television pickup system in existence. Its initial cost is relatively low because of the inexpensive components employed. Operating costs are also low because of the long life and smaller number of components.

In the field of color-television broadcasting, the Vitascan has both advantages and disadvantages. The major disadvantages are rather obvious. It cannot be operated outdoors or where extraneous illumination exists. Multiple camera use will be limited until suitable previewing facilities are developed.

However, certain of its advantages are not obvious until comparison is made with image-orthicon camera operation. For example, typical color studio operation requires illumination levels of at least 100 watts per square foot. In addition, the heat generated presents a formidable air-conditioning problem. The Vitascan, therefore, represents a very significant reduction in operating power costs.

Perfect colorimetric camera match is obtained at all times, since the pickup tubes are common to all scanners. Because of its excellent color reproduction, no special make-up is required with the Vitascan system.

There is no image burn-in, so that a scanner may be left undisturbed on a scene at fixed focus for any length of time. Also, the warm-up and adjustment time required is only a few minutes compared to the hour or longer needed for the image-orthicon color camera.

Fig. 10. Xenon flash lamp fixture.

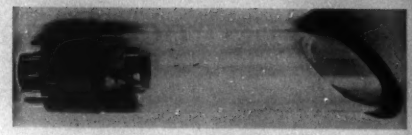

Fig. 11 (top). Miniature cathode-ray-tube strobe light. Fig. 12 (right). Cathode-ray-tube fixture.

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Bedrock Foundations for Manager Development

H. H. RACE

Six essential elements, constituting a firm foundation on which business leaders may build effective manager-development activities, are presented. Dynamic integrative unity is the incompassing concept to be considered, as all the elements need to be taken into consideration simultaneously for effectiveness.

THE ENGINEERING PROFESSION was described recently by Herbert Hoover as follows:

"As a profession, engineering has both joys and sorrows. The engineer has the fascination of watching a figment of his imagination emerge with the aid of science to a plan on paper. Then it moves to realization in cement, metal, or energy. Then it brings new jobs and homes to men. Then it adds to the security and comfort of these homes. That is the engineer's high privilege among professions.

"The profession, however, does have woes. His work is out in the open where all men can see it. If he makes a mistake, he cannot, like the doctor, bury it in a grave. He cannot, like the architect, obscure it by trees and ivy. He cannot, like the lawyers, blame it on the judge or jury. He cannot, like the politician, claim his constituents demanded it. Nor can he, like the public official, change the name of it and hope the voters will forget. Unlike the clergyman, he cannot blame it on the devil.

"Worse still, if his works do not work, he is damned. That is the phantasmagoria which haunts his nights and dogs his days. He goes to bed wondering where the bugs are which will inevitably appear to jolt its performance. He awakens at night in a cold sweat and puts something on paper that looks silly in the morning.

"And the world mostly forgets the name of the engineer who did it. The credit goes to some fellow who used other people's money to pay for it. But the engineer, himself, looks back at the unending stream of goodness that flows from his successes with a satisfaction that few other professions can know."

At the AIEE Summer General Meeting in 1952, T. M. Linville, now a Director of the Institute, presented a paper on "Management of Engineering Work." Also, at the 1955 summer meeting, Clarence H. Linder addressed us on "The Obligations of Engineering Management in a Decentralized Manufacturing Company."

These papers are mentioned because one can read into Mr. Hoover's general statements the realization of the fact that one who manages engineering work carries the full responsibility not only for his own work, but also for all of the work of all of the engineers who report to him. This puts a multiplying factor on the significance of Mr. Hoover's words which is an exponential function of (i.e., greater than directly proportional to) the magnitude and social import of the project headed by the engineering manager.

The focus of attention in this article is on essential ideas which, taken together, constitute a firm foundation which will stand the test of time and upon which the leaders of any business enterprise may build educational activities aimed at helping men develop themselves as managers. Many of these thoughts are equally essential in understanding managerial work itself as a career and a profession worthy of study throughout a man's business life. These ideas came from literature, leaders in business schools, leaders in other businesses, and interviews with over 300 General Electric Company managers. This short summary cannot be exhaustive, it can only point out what appear to be essential elements in the foundation on which the structure of wise future action can be built.

This foundation will be looked at under six phases, namely:

1. Individuality.
2. Universality of opportunity for personal growth.
3. Attention focused on the man.
4. Attention focused on the work.
5. Attention focused on the future.
6. A business enterprise as a dynamic integrative unity.

As a word of warning, it will be recognized quickly that these headings are in many ways interrelated and inseparable. Their consideration in this manner is simply a means for looking at several aspects of our present knowledge of the foundation on which effective manager-development activities can be built.

INDIVIDUALITY

INDIVIDUALITY is a fact. No two people are alike in their interests, attitudes, emotions, abilities, experiences, desires, or inner drives. Furthermore, everyone changes continually so that one individual is not the same today as he was a year or a week ago. Lack of recognition of this fact can lead to, and ofttimes in the past has led to, unfruitful and even undesirable results.

Revised text of an address presented at the AIEE South West District Meeting, Dallas, Tex., April 2–4, 1956.

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Because of these differences between individuals, words and symbols of all kinds mean different things to different people, so that a manager spends a large portion of his time and effort building workable understandings between himself and his associates.

Again, situations change continually. In real life, time is irreversible and the patterns of circumstance do not repeat exactly, although it seems sometimes that one may continue to make similar mistakes because of failure to learn from past experience.

Because no two people are alike, situations change, words and symbols mean different things to different people at different times, every new contact between one individual and another is in some respects a new situation. A manager, desiring to accomplish recognized purposes through people, must adopt an approach which takes into account individuality of people and uniqueness of events. There are principles which can be genuine guides, but specific actions need to be tailored to specific circumstances to achieve greatest effectiveness.

Next, consider individuality in another sense. The way of life in American society, in particular, and the Christian world, in general, is based upon our belief in the dignity and worth of each individual human being. Government is made to serve the people, not people to be servants of the State. In our society, if an institution is to survive, it must be legitimate; that is, it must win the support of those who contribute to and benefit from its activities. A business enterprise is such an institution and, if it is to continue to thrive, its leaders must continually earn its place in society by employing ethical and moral practices through satisfying human needs and treating all people as individuals having personal worth and dignity.

Individuality has another connotation. Each of us, as a mature self-determining adult, is responsible for his own self-development and self-discipline. No one can develop or teach anyone else if the other wills not to learn.

The initiative and desire for learning must come from within one's self. Others can help, guide, and motivate, as well as supply fuel and direction, but the igniting spark to turn external resources into power for growth must come from within the individual.

Growth means change. Growth is natural. The resources for continuing mental growth lie within each individual. Thus, continuing self-development is a natural, normal, and desirable activity throughout life. Those who continue to grow in understanding and ability to the greatest degree reap the satisfaction of personal achievement and, also, contribute most to their business and to society. One definition of success is the degree to which one's accomplishments represent the maximum possible use of all of one's personal resources. Each manager has prime responsibility for his own self-development and, also, for aiding those who report directly to him.

One obvious result of the fact of individuality is that the use of so-called "canned" programs, wherein everyone is subjected to the same externally imposed "treatment," is quite likely to be very inefficient. A more fruitful course is to design educational activities tailored to individual needs. This does not say that groups of individuals cannot profitably work together on common problems or in fields of learning of interest to all, but the individualistic nature of the learning process needs to be a major factor in the design of such educational activities.

This necessity for an individualistic approach should be kept in mind as one considers other interrelated aspects of the foundations on which can be built activities designed to help managers develop themselves.

OPPORTUNITY FOR PERSONAL GROWTH

UNIVERSALITY OF OPPORTUNITY for personal growth has far-reaching implications in its contribution to the foundation on which manager-development activities can be built. This means that opportunities for self-improvement and for advancement based upon merit should be open to every employee who demonstrates: (1) excellence in performance on his present job, (2) evidence of potential for further growth, and (3) willingness to pay the price in personal effort and dedication.

Each manager has a responsibility, not only for his own self-development, but also for helping each individual who reports directly to him as each such individual stretches to develop his own abilities in work of value to his business. The potential for such growth is limited only by the individual's personal performance and the needs of the business enterprise for the work which he can do.

In this age of emphasis on undergraduate and advanced college degrees, valuable as they are as evidences of concentrated study and specialized knowledge, it should be remembered that many able men have not had such advanced educational opportunities. College training does not make an educated man; neither do the number of gold keys worn on his watch chain, nor the number of letters appended to his signature. Regardless of where formal schooling terminates, self-education needs to be a lifelong process; the college graduate is sadly misguided if he thinks at the termination of his formal schooling that he has done much more than learn how to learn. Therefore, the paths for self-improvement and advancement need to be kept open for every individual who consistently and persistently continues his self-development, regardless of where his formal educational stopped.

This concept is drastically different from the "crown prince" or "white-haired boy" approach wherein a few so-called "comers" are selected for preferential treatment.

It is believed that morale, work satisfactions, and total productivity will all be highest if the principle of universal opportunity is known by all and, truly, practiced by managers as they work with and recommend for promotion those who report to them.

Just as strong is the belief that the "crown prince" approach is disadvantageous both for the man receiving preferential treatment and for the company as a whole. Disadvantageous for the individual if his associates are jealous or suspicious, thus producing poor working climate and blocks to good teamwork, or the excellence of his personal performance on assigned work becomes slipshod because he thinks the competition already is won and he need not worry if he coasts for a while. Disadvantageous for the company if many of the 90 per cent or so who are not

on some list of "crown princes" are disgruntled and leave or say to themselves, "What's the use, some fair-haired boy is already slated for the promotion I want, I can't get it anyhow, so I'll coast along and do just enough so that I don't get fired!" Morale and work output would be very low if this were the working climate and general feeling.

Another thought in this connection has to do with the present much-publicized shortage of engineers. A large fraction of the engineers, who now work for a company like General Electric may not be stretching anywhere near the limits of their potential ability because our engineering managers have not adequately challenged their men to achieve such improved performance. Widespread planned effort should be initiated through job enlargement, increased pay, and recognition for those who rise to these greater challenges, and the offering of universal opportunities for growth for those who demonstrate: (a) an excellence in on-the-job performance, (b) an evidence of potential for further growth, and (c) the all-important willingness to pay the price in personal effort. Where the foregoing change can be done thoroughly and consistently throughout an entire engineering department, beginning with the secretaries and draftsmen, general upgrading can result as men capitalize on their abilities and past experience to increase the scope and productivity of their work. By such a general analysis and effort, a company will approach maximum engineering results through the accomplishment of its engineers; also, the engineers will have a sense of job satisfaction, personal accomplishment and recognition, as well as higher salaries.

Again, before considering implications in terms of company-wide activities, this idea of universality of opportunity for personal growth should be compared with that of individuality, while three more headings of a slightly different kind are considered.

ATTENTION FOCUSED ON THE MAN

THE THIRD THOUGHT is that a manager's attention must focus on the man. By definition, a manager is one whose principle work is leading the men in his component and getting the work of the component done by and through the men who report directly to him. If what he does is to be done in the best possible manner, every thought and action must be based not only upon the work of the component, but also upon concern for and understanding of the men and women who comprise the component and upon whom future performance depends. This leads directly to the recognition that not only must a manager know enough of the physical sciences to understand the technical aspects of the work of the component, but also that he must know enough of the human sciences to accomplish results through other men. Thus, as a manager develops himself, regardless of his previous technical training, he needs to study and acquire a working knowledge of economics, psychology, sociology, government, philosophy, ethics, and religion—the accumulated heritage of how men have learned to live together and associate their efforts in group undertakings for mutual benefit.

Again, lifetime self-education is indicated. Whatever an individual's formal schooling may have been, he needs to continue his studies along two parallel lines: first, in the technical or functional field in which he is specializing, such as electrical engineering, if he is to become a leader in his chosen field of work; and, second, in the broader economic, social, and political fields which pervade and encompass his technical work, if he is to understand the environment within which his business operates and learn how to work effectively with his fellows in a common enterprise. This latter area of self-education is of paramount importance if the individual aspires to a position in which he manages the work of others. Continued self-education in the social sciences is a must, because no amount of theory is sufficient. Understanding and true learning result from applying theory to practice, as well as from actually performing the actions which lead to better working relationships between people and to better teamwork toward achieving chosen goals. It is through study of theory and application of principles to working situations that a manager can make use of the accumulated wisdom of man's progress as a social being, as recorded in writings in fields such as economics, psychology, philosophy, sociology, ethics, and religion.

Much of the literature on managerial subjects is based on what appears to be a fallacy, namely that managerial work can be classified into two parts—the so-called "mechanistic" and "humanistic" parts. Our efforts to define and describe managerial work started out this way, but it soon became apparent that this approach should be abandoned as a superficial, artificial, and unrealistic separation. There is no part of a manager's work which can be done effectively without concern for and knowledge of the men and women who contribute to and benefit from the work being managed. For this reason, "human relations" is not separated at any particular part of the description of managerial work. Human relations are inherent in all parts of such work. Thus, it is an essential aspect of a solid foundation for manager-development activities to have the focus of attention on the man—his feelings, attitudes, behavior, and motivations.

ATTENTION FOCUSED ON THE WORK

THE NEXT THOUGHT on which to focus attention is work. The first and obvious reason is that the prime objective of managerial effort is to achieve the purposes, accomplish the objectives, and bring to fruition the results which have been set for the component or enterprise being managed. If desired results are to be realized, the manager must consider all aspects of the work which is necessary to convert desires and possibilities into accomplishments.

Another reason for focusing attention on work is that one learns best by doing. Intellectual study, understanding, and acceptance of new ideas is necessary, but is not enough. One has not really learned something new until one can and does put the knowledge into practice. Growth means the acquisition of new knowledge and new skills, as well as modifying and building on the old. Learning means converting mental growth into a way of life. Thus, understanding can best be achieved in an educational activity for adults if individual study, individual work, and informal and planned group discussion are combined

with lectures and presentations. Thus, learning is not completed until new ideas are put into practice in day-to-day work on the job. The fruits of the learning process show up in performance; therefore, a manager's thoughts and actions need to be work focused.

ATTENTION FOCUSED ON THE FUTURE

THE FIFTH ASPECT of our foundation for manager-development activities is that a manager's attention needs to be focused on the future. To say that conditions are always changing is commonplace. But is it realized how fast they are changing; how great will be the impact of rapid world-wide, economic, social, and political changes on our own business situations; and how great will be the impact of rapid technological developments on managerial work. The present is a time of extremely rapid world-wide change in almost all areas of technical development and also of human relationships.

A period is being entered in which managerial work itself is under intense study. As the great potentialities for improvement in performance of this kind of work become recognized, the practice of management itself will change markedly. Also, simultaneously with the recognition of increasing complexity of situations necessitating business decisions, there are being developed marvelous tools for analyzing and processing data, which can be used by managers to provide for themselves hitherto unobtainable information upon which to base business judgements. Again, as mechanization and automation become increasingly more characteristic of mass-production industries, the size of capital commitments, time span affected, and the risks involved in managerial decisions are very greatly increased. Furthermore, the recruitment of workers of all kinds who have requisite abilities, as well as the education and time needed by them to acquire requisite new skills, becomes an ever increasing concern of managers.

These facts mean today's managers need to study and understand the opportunities and challenges which the future is likely to bring, if they are to make right decisions.

DYNAMIC INTEGRATIVE UNITY

THE SIXTH and all-encompassing thought in looking at bedrock foundations for manager-development activities is that of dynamic integrative unity. A favorite quotation of a good friend of mine is, "Words are but empty vessels into which meaning must be poured." Therefore, let us look at the three words in this thought. First, consider the noun "unity"—the following related dictionary definitions add to an understanding of the meaning of the word: (1) state of being one; oneness; singleness; (2) concord; harmony; conjunction; agreement; accord; uniformity; as a unity of sentiment, proof, doctrine; (3) a uniting or being united into one body; unification; hence, a body formed by union; (4) a quality or fact of constituting a whole; a totality of related parts; a complex or systematic whole; and (5) a thing that is or seems complete in itself. Each component in a business enterprise is a "unity" in itself, comprised of smaller unities which, in turn, are teams of individuals having differing abilities and interests.

The "unity" comes about because the individuals, who make up such teams and progressively larger unities, are working together toward common purposes of mutual benefit to all. This progression is extended until the whole business enterprise becomes a "unity" in the environment of our society. At this point, the many means for building such unities will not be considered, except to say that individuals must understand and accept the common purposes before they can make their maximum contributions.

Consider the adjective "integrative"—one might think at first that this is unnecessary redundancy because the concept of unity inherently includes the integration of parts of the whole. The suffix "-ive" gives the clue as to why the modifying adjective is used. The word "integrative" describes the kind of a unity being discussed—a unity into which, by purposeful design, integrating forces are provided and channels for integrative action have been built, which lead naturally toward ever more effective teamwork. Examples of these built-in integrative influences thus are: (1) emphasis on having clearly stated and well-understood objectives and goals for the entire company, as well as for each component, in order to focus the efforts of all employees toward the accomplishment of desired results; (2) parallel emphasis on "teamwork," as well as "own work" responsibilities and accountabilities in all position guides; (3) emphasis in decision making on balancing the best interests of all concerned; (4) emphasis on thinking company-wide when proposed decisions affect people outside of one's own department; (5) emphasis in all services on researching and teaching in their respective fields, so as to help all departments in keeping ahead of competition; and (6) emphasis of all company officers on balancing and promoting company-wide best interests.

These examples have been cited to show that General Electric and all of its departments and divisions are being designed to be self-integrating. Therefore, the company can be described as an integrative unity.

Now for the adjective "dynamic"—nothing is more changeless than the inevitability of change. Growth means change. Nothing animate is the same today as it was yesterday, nor will it stay alive without further change. All this is obvious, and recognition of the implications is vital to the future progress of a company and the well-being of all its employees. Thus, the thinking of all planners, organizers, managers, and leaders in all kinds of work must be dynamic and forward looking, if the results of efforts are to measure up to opportunities. Purposeless change is futile, but beneficial innovation is the lifeblood of progress. A business enterprise must continue to be dynamic, if it is not to ossify and die.

All of the ideas expressed in this article need to be taken into consideration simultaneously if manager-development activities are to be most effective. Therefore, "Dynamic Integrative Unity" is the encompassing concept which fuses together the bedrocks of individuality, universality of opportunity, focusing attention on the man, the work, and the future in the self-education of managers.

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Anomalous Flashovers on Transmission Lines

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TWO POWER COMPANIES recently have experienced outages caused by lightning far in excess of the rate predicted by usual methods. Furthermore, it has been found that most of these outages are caused by the flashover of top or middle phase insulator strings on towers with very low footing resistance, which represent phenomena contrary to the usual theory. Many of these insulators have lightning-produced glaze burns, which hug the porcelain surface on both sides of the disk, even into the depths of the grooves between petticoats. This characteristic, coupled with laboratory experience in impulse testing, suggests that the lightning voltage pulses which produce these glaze burns have very steep fronts, and that in a fraction of a microsecond they probably reach crest potentials considerably in excess of the usual $1^1/_2 \times 40$-microsecond-wave critical flashover voltage. Marks found on tower tops show where they have been hit by lightning strokes, and it is this observation which rules out the possibility that these anomalous flashovers may be because of shielding failures.

In the high-voltage laboratory of the Ohio Brass Company Barberton, Ohio, a 3-million-volt impulse generator, without series resistance and charged to 2.5-million volts, when discharged into a 22.5-foot section of an angle iron tower leg, as shown in Fig. 1, produces enough voltage across it to flash over a 3-unit string of suspension insulators connected in parallel with it. Glaze burns produced on the units in this test show the same surface-hugging characteristics found in field units.

Fig. 1. Flashover of a 3-unit insulator string shunted by an angle iron tower leg.

A photograph of a 12-unit insulator string shunted by a rod gap, which chopped the steep-front voltage wave from the 3 million volt impulse generator just prior to flashover of the string, shows that 8 of the 12 units have practically flashed over, and that flashover is imminent on the 4 remaining units. This test and many like it indicate that each unit in a string builds up to flashover simultaneously, and suggests the idea that a long string of insulators may flash over in almost as short an interval of time as that required for the flashover of a single unit. This leads to the conjecture that a "fractional-microsecond flashover" may occur on a string in the field when it is subjected to a steep-front voltage pulse of sufficient magnitude.

Using traveling-wave theory, it can be shown that a lightning stroke to a tower top can produce at that point a potential with respect to ground, that in a fraction of a microsecond can reach a crest value many times higher than the maximum tower-base voltage, which in turn is determined by the product of footing resistance and maximum tower current. When the first wave reflected from the tower base returns to the top, it alleviates the voltage build-up at that point; as a result of this and successive reflections, the tower-top potential merges with the tower-base voltage within 1 microsecond. Factors which tend to increase the tower-top voltage include an increase in tower heights, an increase in the steepness of the front of the voltage or current wave, and an increase in the ground-wire surge impedance.

The voltage across an insulator string is the difference in potential which each end has with respect to ground. The upper end has the potential of the supporting crossarm, which depends upon its location on the tower. The lower end has the potential of the phase wire as determined by the 60-cps line-to-ground voltage. This voltage may add or subtract to the crossarm potential and, hence, at times may cause a greater voltage across a middle phase than across a top phase string, thereby causing it to flash over occasionally.

Recognition of the causes of these anomalous flashovers will undoubtedly result in a renewed interest in the flashover characteristics of line insulation in the region below 2 microseconds, and reinvestigations of the design factors for high-voltage transmission lines.

Digest of paper 56-201, "Anomalous Flashovers on Transmission Lines," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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Development of Communications in Canada

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CANADA'S ENORMOUS AREA, consisting of almost 4-million square miles, makes it the third largest country. Natural barriers separating the populated areas prevented the establishment of a transcontinental telephone system until 1932.

The experience of the Trans-Canada Telephone System, representing the seven major telephone systems in Canada, in developing a transcontinental telephone network is described. The operational problems are discussed inasmuch as they were the most difficult to resolve.

The route followed across the continent is shown in Fig. 1. It extends from the Atlantic to the Pacific Oceans passing through all the key cities; the over-all distance is about 4,200 miles. In the thinly populated thousand-mile section north of Lake Superior (between Sudbury and Winnipeg) and through the Rocky Mountains, arrangements were made to carry the telephone circuits on the Canadian Pacific Railway pole lines, thus avoiding the need to build duplicate pole lines in these difficult sections.

The initial development of the route was on an open-wire and type *C* carrier basis. As much use as possible was made of existing toll leads, but in order to meet the strength requirements of a Class A line, it was necessary to rebuild some 2,000 miles of line.

The transmission objective was to meet the limits of the general toll switching plan proposed at the time. To this end, the best available grade of outside plant was constructed using 165- and 128-mil copper wires on type *CS* insulators, with 8-inch spacing between wires and a minimum of 16-inch spacing between pairs. The two top crossarms on the lead were reserved for the large gauge wires used for long haul circuits. This necessitated the relocation of existing 104- and 114-mil pairs on lower crossarms. Between Halifax and Vancouver there were 22 intermediate repeater points. The average repeater spacing was 180 miles and the longest sections 250 miles in length.

The *C* carrier capacity of the line was exhausted in the early years of World War II, when there was about 30,000 system miles of *C* carrier in operation. Of this network about 60 per cent was made up of systems 1,000 miles or more in length. The longest of these was 2,170 miles. The next step was to develop it for *J* carrier operation.

This development presented several unusual features. These included the length of the systems involved and the 1,000-mile section between Sudbury and Winnibeg where the telephone circuits are carried on the railway pole line. This latter situation imposed complex problems of electrical and physical co-ordination, one of which was the presence of signal wires on the pole line which could not be interfered with even though they were tertiary paths contributing to crosstalk and singing. In addition, a wide range of weather conditions comprising sleet, freezing rain, and wet snow in some sections, as well as hoarfrost in others, had to be allowed for in designing the system. The Rocky Mountains in the West presented many difficulties among which were snow and rock slides that buried or carried away extensive sections of pole line. There were also power supply and accessibility problems, as well as voltages between wires and ground of 500 to 1,000 volts caused during magnetic storms.

The design which was adopted involved retransposing the *J* pairs all along the route to the *J5* or *K82* design and construction of a new 80-mile section in the Rockies to minimize the effect of snow and rock slides. Spacing of the repeater stations varied from 30 to 70 miles depending on the probability of ice incidence. The layout was designed to overcome line losses of from 1 to 2 db per mile, and aimed at limiting outages to not more than 5 to 10 days per year.

Many special measures were applied to control singing, noise, and crosstalk and to ensure protection, in order to provide the best performance and greatest freedom from service interruptions that was economically feasible.

Maintenance of the facilities in the undeveloped 1,000-mile section on the railway line presented many problems involving staff, transportation, housing, gasoline engine driven generators, and others. While these have all been resolved satisfactorily some of the solutions are unique in telephone annals. Even though carrier systems of 1,000 miles or more are in operation, maintenance is good.

The open-wire line has been developed to its maximum capacity. Long-term relief is being provided through the construction of a coast-to-coast radio relay system carrying television and *L* carrier facilities. Over-all completion of this new structure is scheduled for late 1957 or early 1958. The additional circuits required for direct distance dialing will be furnished economically over the new radio relay structure.

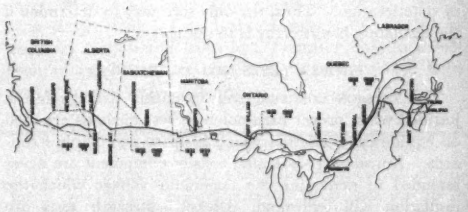

Fig. 1. Trans-Canada Telephone System toll routes

Digest of paper 56-244, "Development of Transcontinental Communications in Canada," recommended by the AIEE Committee on Wire Communications System and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Scheduled for publication in AIEE *Communication and Electronics*, 1956.

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High-Potential Testing of Aircraft Equipment Electrical Insulation

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Recent investigations of air-gap breakdown through holes in insulating materials, simulating faults in aircraft equipment, have produced valuable facts, such as those regarding dielectric fatigue, minimum test voltage, and transient voltage effects. However, need for testing at later stages is not eliminated, as during the various manufacturing processes, storage and use, damage or deterioration may be introduced.

TWO METHODS ARE KNOWN for finding out whether aircraft-equipment insulation is adequate: one is to wait for service failures, and the other is to test it properly. The high-potential dielectric test is the principle means of detecting holes, cracks, discontinuities, metal inclusions, and other flaws in insulation. Because all insulating materials contain flaws, are subject to damage in fabrication, deteriorate with age, and since material inspection is never 100 per cent perfect, properly engineered electrical insulation can and does fail.

The detection of an insulation fault at the earliest possible stage minimizes the cost and hazard. An inspection defying 0.003-inch diameter "pin hole" or crack where the insulation was intended to lap, if detected when the coil is first assembled on the core, will cost the least to correct. If the test is not made at this point, man-hours are added to this faulty part and the cost goes up and up. Likewise, after a faulty insulated coil is impregnated and baked, or after assembly of a complete machine, or at the customers receiving inspection, the cost is multiplied at each stage. Finally, if this insulation fault is not discovered until failure in flight, truly high penalties may result.

Rigorous insulation quality control at any or all preceding stages may not eliminate the need for high-potential testing at later stages. In the progress of producing an aircraft electric component from the basic materials through usage to the scrap heap, the various stages of manufacture and usage all introduce the possibility of insulation damage or deterioration. Thus, the only sure way to determine if the insulation is airworthy is to test it.

PROPER TESTS NOT INJURIOUS

THE COMMON CONCERN over insulation damage is not justified when proper high-potential test methods are used on equipment insulation which is up to acceptable standards. Normal high-potential tests of equipment are never intended to determine the maximum voltage which the insulation will withstand. Dielectric-strength tests are normally applied to insulation materials, but not to fabricated equipment. The entire purpose of equipment dielectric test should be to discover flaws in the insulation. Therefore, a high-potential test voltage should be high enough to discharge through a hole in the insulation, but not high enough seriously to stress solid insulation materials or surface air gaps designed to acceptable aircraft dimensions. The better aircraft insulation materials have breakdown potentials in excess of 1,000 volts per mil. It is obvious, if 0.003-inch insulating material contains a pinhole, that the potential required to breakdown this air gap will not seriously stress either the solid insulation or normal air gaps in the equipment. Marginally thin insulation will, however, be detected. A voltage sufficient to break down a 0.003-inch air gap may puncture insulation which is dangerously thin. Solid insulation can be dangerously thin because switching transients often cause high voltages in the normal operation of the equipment.

Because inductive-circuit interruption transient voltages may reach values of more than 1,000 volts, it is, indeed, important that high-potential test voltages should detect holes, cracks, and marginally thin insulation. If these discontinuities are not detected by high-potential test, then, in operation, inductive-circuit interruption transients are very likely to discharge through these flaws or puncture marginally thin insulation and cause insulation failure by tracking.

Repeated dielectric stresses do produce voltage fatigue failure of insulation. However, it is not justifiable in coming to the conclusion that repeated high-potential tests of equipment are, therefore, damaging and undesirable. In the first place, this phenomena is analogous to fatigue failure in metals. There is a voltage fatigue limit effect with voltages below this limit in value, producing a negligible effect on insulation. While far too little is known about voltage fatigue limit values for aircraft insulation, it is safe to say that proper dielectric-test procedure will not even closely approach this limit for acceptable thickness of insulation, where the test voltage has been selected to discover holes in the insulation and, therefore, is maintained substantially below the ultimate dielectric strength of the material. For example, the dielectric strength of a 3-mil thick section of "mylar" at 150 C is given as 3,000 volts per mil. Dielectric fatigue effects for 10,000 or less repetitive voltage stresses disappeared at approximately 80 per cent of the breakdown voltage for this material; in this case, 9,000 volts. So repeated dielectric tests at less than 7,000

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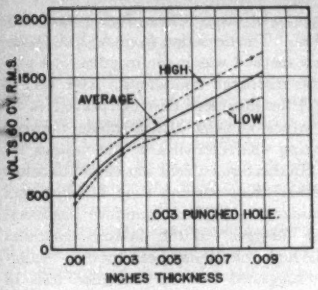

Fig. 1. Dielectric breakdown voltage of holes in 0.003-inch thick mylar insulation. Ten "Hi-Pot" tests made at each indicated thickness. Solid line indicates average breakdown voltage; dotted lines indicate maximum and minimum breakdown voltage.

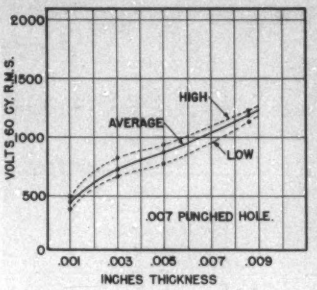

Fig. 2. Dielectric breakdown voltage of holes in 0.007-inch thick mylar insulation. Ten "Hi-Pot" tests made at each indicated thickness. Solid line indicates average breakdown voltage; dotted lines indicate maximum and minimum breakdown voltage.

volts would be unlikely to affect a measurable reduction in the breakdown voltage of this insulation. When it is considered that the proper dielectric test for this insulation would be 2,000 volts or less, and similar stresses to this might occur in operation as a result of switching transients, it seems unjustified to limit the use of the high-potential test technique on the basis that insulation damage is likely to occur.[1,2,5,7]

MINIMUM TEST VOLTAGE

FAILURE ANALYSIS of 28-volt equipment repeatedly demonstrated that 500-volt 60-cps a-c tests were not detecting insulation flaws which subsequently cause service failures. Circuit interruption transient voltages discharged across the insulating materials discontinuities which the standard 500-volt test potential had failed to discover. It was realized that simple calculations, made on the basis of the air gap, demonstrated that 500-volt high-potential tests were not enough. Existing information could have provided the basis for approximate determination of dielectric test voltages. However, such determinations left a lot of doubts and unanswered questions.

An experimental investigation of the subject, concerning breakdown voltages of air gaps through small-diameter openings in present aircraft insulation was undertaken. It was anticipated that the following factors might alter or affect the breakdown potential through insulation flaws: (1) voltage gradients in the gap area caused by the change in dielectric constant from insulating material to air at the edges of the hole; (2) limited dissipation of the heat of discharge caused by loss of convection cooling and surrounding the gap with insulating material; (3) contamination of the air-gap area with products of the discharge from the metals and insulating materials; and (4) air-gap pressure changes caused by confining the discharge in small holes. Although individual analysis of these and other factors possibly affecting air-gap breakdown through small holes in insulation was beyond the scope of our investigation, an over-all experimental determination of the combined effects was made.

Various sizes of holes in a range of commonly used thicknesses of mylar, "teflon," mica, and vulcanized fiber (fish paper) were tested for breakdown voltage under carefully controlled conditions. Hole diameters used were 0.003, 0.005, 0.007, and 0.009 inch (Figs. 1 and 2). Insulation material thickness was varied for each size of hole from 0.001 to 0.009 inch in commercially obtainable steps. The test jig shown in Fig. 3 was constructed in accordance with American Society for Testing Materials (ASTM) *D149-44* specifications for the test of insulating tapes with opposing cylindrical-rod electrodes, 1/4 inch in diameter with edges rounded to a radius of 1/32 inch, resting on the insulation with a force of 1/10 pound. The electrode surfaces were polished to a 10-microinch finish and were repolished after each discharge. It was found that consistent results could not be obtained unless extreme care was used to avoid contamination of electrode and insulation surfaces. A fingerprint could alter results beyond use. Medical operating theater type care and cleanliness was required. Because the dielectric breakdown voltage of the air gap in the holes in the insulation was under investigation, temperature and humidity changes had no significant effect on the result. To check this point, similar voltage breakdown tests of 0.003-inch holes in 0.003-inch mylar tape were made at 125 C and at room temperature. The differences between the two series of tests were all within the ±20-per-cent repeatability range of the test procedure. To those not familiar with this type of test, a ±20-per-cent repeatability of air-gap breakdown-voltage data is not easy to achieve. The technique of punching uniform-diameter holes without thickening the insulation around the hole in materials which tend to flow, such as mylar, is a real problem. Microscopic measurement of each hole diameter and thickness must be made to secure repeatable results.

Dielectric breakdown voltage of holes in mylar insulation shown in Figs. 1 and 2 are typical of all the insulating materials. It is to be noted that a 500-volt rms 60-cps high-potential test, currently used on much aircraft equipment, would not detect a flaw reliably in insulation thicker than 0.001 inch. One-thousand rms volts would be required to detect a 0.003-inch diameter hole in 0.003-inch of insulation. As expected, larger diameter holes broke down at lower voltages.

DISCHARGE THROUGH INSULATION HOLES

TO RELATE THE OBSERVED FACTS directly to aircraft-equipment operation, a typical aircraft circuit was set up so that the circuit interruption transient voltage could be

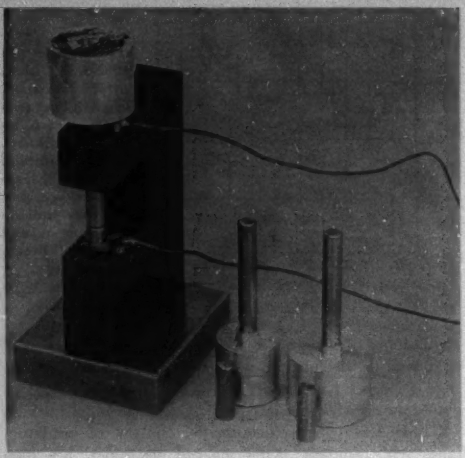

Fig. 3. Test jig for testing breakdown voltage and tracking of insulation.

applied directly to a 0.003-inch hole in 0.002-inch thick mylar insulation under the conditions specified. A standard 28-volt fire-extinguisher solenoid, producing a maximum circuit interruption 1,000-volt transient discharge, was applied to the jig (Fig. 3). Complete tracking to a low resistance below a thousand ohms occurred in a single discharge. When this test was repeated with 20 fresh samples, in no case did it take more than 10 discharges to produce insulation failure. The seriousness of this observation is indicated by the fact that it took 100 to 200 similar discharges across the machined surface of a fabric-base aircraft-quality phenolic insulation to produce a similar failure. The energy in the circuit interruption voltage transient of this fire-extinguisher solenoid was 7 watt-seconds, but the maximum rate of energy dissipation was 338 watts. It is the high rate of energy dissipation in circuit interruption transient spark-overs that is so damaging to insulation. The electrodes used during this part of the test were made of brass. It appeared that: (1) either mylar had exceptionally bad tracking characteristics, or (2) the tendency to produce tracking was greatly increased by confining the discharge to a small enclosed area.

Investigation of small-hole tracking of some insulation materials was undertaken to answer the questions raised in connection with the fire-extinguisher solenoid switching transient test, as described. Referring to the schematic circuit diagram of Fig. 4, the test jig of Fig. 3 was connected to a standard 2,500-volt high-potential dielectric test instrument which provided close control of both voltage and current. Breakdown voltage was continuously controllable from zero to 2,500 volts and the discharge current was continuously controllable from 50 microamperes to 20 milliamperes. An automatic timer was connected so that discharge time was controlled for $2^1/_2$-seconds ON and $2^1/_2$-second OFF periods. This timing cycle allowed stable meter readings to be taken before, during, and after each discharge period. The deviation from ASTM *D495–42* arc resistance test method was made to adapt the procedure to small-hole discharge conditions. The ASTM method, specifying 10-milliampere current, proved to be in excess of values which allowed distinguishing between the small-hole tracking characteristics of the various insulation materials. In this test, current was varied to below 10 milliamperes rather than varying time of discharge. A control relay connected a 500-volt standard insulation resistance-measuring "megger" to the dielectric material immediately after the high voltage had been cut off. Tungsten electrodes are suggested for arc resistance tests in ASTM *D495-42* specification, so the test jig in Fig. 3 was initially set up with tungsten electrodes of the same dimensions as before, 1/4-inch diameter with 1/32 radius on the material contacting ends and a 10-microinch polish. Because results with the tungsten electrodes did not correlate with the brass electrodes first used, the subject of electrode material effect was checked. Electrodes of copper and iron were also used to more closely simulate actual breakdown conditions in aircraft equipment.

Referring to Table I, it will be noted that a 4-milliampere discharge through a 0.003-inch hole in teflon could be repeated for five-hundred $2^1/_2$-second periods with tungsten electrodes, while a similar discharge using iron and copper electrodes failed the insulation in four $2^1/_2$-second discharges. Mylar and mica also showed a drastic reduction in small-hole tracking resistance when copper and iron electrodes were used. Since the tracking resistance of mica is generally considered to be very high, it was surprising to find a 4-milliampere discharge failing the insulation in ten $2^1/_2$-second cycles. Under the same conditions with tungsten electrodes, the mica holes were able to withstand two-hundred $2^1/_2$-second discharge cycles. From the data obtained in this test the following conclusions were reached: (1) Electrode metals for small-hole tracking tests are critical and if the results are to correlate with operating experience, then the electrode materials must more nearly correspond to that in the equipment. (2) "Tracking" failure through flaws in insulation occurs much more readily than over the surface of insulations. (3) Copper and iron electrode surfaces in a discharge through small holes in insulation will cause tracking resistant materials such as mica to fail rapidly. (4) Common circuit interruption switching transients contain enough energy to immediately fail insulation when discharging through small diameter holes.

IMPORTANT BACKGROUND FACTORS

THE EFFECT on aircraft-equipment reliability of this small-hole insulation breakdown and tracking phenomena is best appraised against a background review of: (1) the factors causing electrical insulation deterioration, and (2) circuit interruption transient voltage effects.

The fact that an insulation, at some stage of its manufacture, has passed adequate inspection and test is not surety that even in storage the insulation will not have deteriorated to the point where the equipment is no longer airworthy

Some of the factors causing electrical insulation deterioration are the following:

1. Time-electrochemical reactions with air, etc.

2. Evaporation of plasticizers from plastic insulation materials causing embrittlement, leading to subsequent vibration failure of the insulation.

3. Moisture is more likely to damage nonoperative equipment, since the heat of operation tends to dry out operative electric equipment.

4. Electrolytic deterioration—electrolytic corrosive action, to which metals are subject, tends also to promote the deterioration of electrical insulation in the vicinity where the corrosive actions occur, because of the metallic salts generated. Many insulating materials themselves, when subjected to potential differences in the presence of high humidity, rapidly deteriorate.

5. Heat—high temperature deteriorates electrical insulation. Heat greatly accelerates the changes mentioned under several other heads in this list.

6. Thermoplasticity and "cold-flow" effects caused by temperature and pressure often cause thinning or flowing of insulation to an extent, producing ultimate failure of an originally acceptable insulation thickness. Thermoplastic and cold-flow effects are a function of time as well as temperature and may occur very slowly in operation.

7. Inductive-circuit interruption voltage transients may reach values of more than 1,000 volts. These voltage surges, when present, are likely to puncture insulation if winding pressures, thermoplasticity, or cold-flow effects have reduced insulation thickness below critical values. For many commonly used insulation materials and circuits, insulation thickness of less than 0.002 inch may be critical. Failure in 28-volt circuits is not immediate from such punctures, but ordinarily occurs as the result of repeated interruption transient discharge through the initial puncture, causing "tracking" of the insulation around the edges of the hole. Proper high-potential test procedure will often discover these usage-developed faults before failure.

8. Tracking, or the buildup of a conductive path across surface gaps because of carbonization of an insulator by repeated circuit interruption inductive surge discharges, is a major cause of insulation failures.

9. Corona discharges rapidly deteriorate some types of commonly used aircraft electrical insulation. At high altitude, corona discharges occur at much lower voltages than at sea level, making this consideration an important factor in aircraft insulation deterioration.

10. Surface contamination of the materials used for testing.

Table I. Insulation Failure through 0.003-inch Diameter Holes, Showing Effect of Electrode Materials

Insulation Material	Current in Breakdown, Milliamperes	Number of Cycles before Insulation Failure: Tungsten, Tungsten Electrode	Iron, Copper Electrode	Iron, Iron Electrode
Mylar	0.031		31	
	0.031		1	
	0.031		9	
	0.062		3	27
	0.062		4	11
	0.062		1	10
	0.062		2	
	0.125			8
	0.125			5
	0.25			3
	0.5	150*		1
	1.0			9
	1.0			1
	1.5			2
	2.0	250*	1	
	2.0		1	
	2.0		1	
	3.0	350*		
	3.0	500		
Teflon	0.5		90	
	0.5		202	
	0.5		250	
	1.0		90	
	1.0		60	
	2.0		15	
	4.0	500*	4	
	4.0	500*		
Mica	0.5		28	
	0.5		28	
	1.0	200*	25	
	1.0	200*	20	
	2.0	500*	21	
	2.0	215*	16	
	4.0	187	10	
	4.0	208	11	
	20.0	8	2	
	20.0	14	4	

Note: * Did not fail. One cycle = 2½ seconds "ON" and 2½ seconds "OFF".

Circuit interruption voltage transients severely stress the insulation of not only the inductive item of equipment generating the surge, but also the cable, terminals, connectors, resistors, capacitors, etc., in the circuit from the hot side of the inductance to the load side of the switch opening the circuit. Thus, noninductive items of equipment used in inductive circuits may be affected.

Substantial data[2] show transient voltages in excess of 3,000 volts for 28-volt circuits, interrupted with a snap-action double-break air-gap switch. A detail investigation of this problem has resulted in the following observations:

1. A typical interruption cycle for an aircraft circuit may be of 10-milliseconds duration. An arc is initially formed as the contacts open. During the period of this arc, the current falls at a relatively slow rate until a critical arc current value is reached, below which a gaseous discharge will not be maintained. At this point, an abrupt discontinuity in the current flowing in the circuit will occur as the discharge extinguishes. It is the current discontinuity and accompanying rapid change in flux,

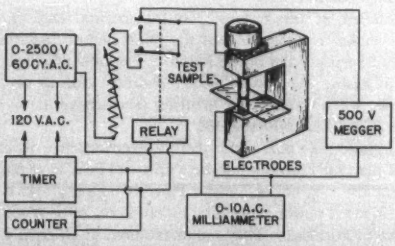

Fig. 4. Schematic diagram of test setup for testing breakdown voltage and tracking of insulation.

which produces interruption voltage transients of some concern. If the total circuit interruption time is 10 milliseconds, it is likely that this final voltage transient producing current flow discontinuity will be a few microseconds. The resulting high-voltage microsecond transient may ionize the gas in the switch gap and restrike the arc, repeating the foregoing cycle.

2. When the circuit interruption transient is computed from the familiar relation $e = -N\ d\phi/dt\ 10^{-8}$ volts or any other derivation of Faraday's law, an improper conclusion may result. Computation on the basis of any total circuit interruption time of the order of milliseconds will produce a misleading, low figure likely to be as small as 10 per cent of the probable actual circuit peak values. The possible peak transient values may be computed for the microsecond periods of abrupt current change in the circuit interruption current characteristic. When this is done an equally misleading high value of the order of 5,000 to 10,000 volts is obtained. Actual circuit interruption voltage transients are normally neither as low nor as high as computation would indicate for reasons suggested below. Furthermore, computation of the emf of self-induction, rather than practical laboratory investigation, has led to the false conclusion that switching voltage transients will vary as the system voltage. This spurious conclusion has been used to support the establishment of various high-potential test voltages for comparatively small differences in nominal system voltage, such as a 500-volt high-potential test for 28-volt systems.

3. Actual circuit interruption voltage transient values are determined by the minimum instantaneous voltage breakdown at the weakest point in the circuit from the inductive source of energy to the switch gap. In a properly designed circuit, the breakdown voltage of the switch gap at an instant of circuit interruption discontinuity should be less than the breakdown voltage of any other voltage transient stressed part of the circuit.

4. A 28-volt system voltage transient will not differ substantially from other higher voltage aircraft systems, since, in every case, the actual observed values are really determined by voltage breakdown of the switch gap or some other part of the circuit. As pointed out, the theoretical values computed from the maximum rate of current change are likely to be above 5,000 volts, so that it is always the switch gap or other insulation breakdown that determines the actual circuit values measured. While the static voltage-breakdown values of switchgear for the various systems may be substantially different, the operating condition at or near deionization of the switch gaps is not likely to differ substantially.

5. Measurement of the circuit interruption transient voltage requires the use of oscilloscopes, voltage dividers, and recording cameras, capable of calibrated response to higher than a megacycle.

6. High frequency, as well as the high voltage of circuit interruption voltage transients, is a key factor in measurement control and understanding of these phenomena. With voltage changes of the order of 100 volts per microsecond, it is obvious that circuit capacitance, dielectric losses, and core losses are key factors.

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Powermaker Ups Production on Formosa

Aluminum and fertilizer production in the city of Kaohsiung, located on the strategic island of Formosa, is expected to increase considerably as the result of the electric power which will be received from this 44,000-kw steam turbine-generator unit.

Installed at the nearby Nan-Pu thermal station, the powermaker will supplement the hydroelectric facilities in the southern portion of the island. The new machine will aid in easing the annual power shortage during the dry seasons, when water in the artificial lakes above the hydroelectric units is extremely low.

Purchased as a part of the over-all electric-power development plan for Formosa, the new unit will be a vital part of the rapidly expanding Taiwan Power Company. It is the highest rated power generating machine yet to be placed in service in Formosa. It was manufactured at General Electric Company's medium steam turbine, generator and gear department in Lynn, Mass.

Operation of Large Steam Turbine-Generators

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MODERN STEAM TURBINE-GENERATORS are complex pieces of equipment designed to operate continuously for long periods of time without shutdown. To operate one of these large generators properly requires the close following of operating guides and procedures for the particular type of unit. This article presents some recommendations by design engineers on procedures to be followed in starting, operating, and maintaining large, conventionally cooled turbine-generators.

Many special mechanical and electrical checks should be made during the installation period. Insulation resistance readings should be taken to determine whether it is necessary to dry the machine out before applying voltage. Although insulation resistance readings do not give complete information on the condition of the insulation, such measurements do give valuable information as to the surface condition of the winding, and aid in indicating whether the winding has become damaged. However, insulation resistance readings must be taken with great care since the readings vary with the winding temperature and the time of application of voltage; temperature corrections to put all readings on the same base may be made. Much valuable information can be gained by charting the history of the insulation.

The output of a generator is limited by the maximum temperatures and thermal stresses which are allowable in the various parts of the machine. At loads which cause higher temperatures or thermal stresses than the design limits, there will be accelerated breakdown of insulation or other parts which can cause early failure of the machine. Unfortunately, it is not feasible to locate temperature detectors at the various critical spots to determine the exact temperatures under normal loading conditions; therefore, it is necessary to extrapolate from other temperature measurements and to use guides or curves to achieve proper operation.

Resistance temperature detectors are installed in the armature windings to provide a means for measuring operating temperatures. The major portion of the heat generated in the armature conductors is dissipated through the insulation into the armature iron, the remainder escaping into the ventilation ducts, wedges, and end turns. The flow of heat through the insulation creates a temperature drop from the copper conductors to the resistance temperature detectors which are located outside of the insulation. This temperature difference varies with the configuration of the slot and conductor, the thickness of insulation (or voltage class), and the current flow.

The generator reactive capability curve, which plots kilowatts versus kilovars for various hydrogen pressures and for power factors from zero lagging to zero leading, is designed to limit temperatures and thermal stresses in all parts of the machine to safe design limits when the cold-gas temperature is maintained within normal limitations. Therefore, normal loading should be based on the capability curve, with the temperature detectors used as indicators or alarms.

Generators are normally designed for cooling water temperatures higher than the usual water supply temperature. However, when the water supply temperature is higher than the design temperature, the load must be decreased, or the hydrogen pressure increased, in order not to exceed the designed operating temperature limitations. A simple formula to accomplish this is that for each Fahrenheit-degree increase in water temperature above normal, the load should be decreased one per cent or the hydrogen pressure should be increased 1 pound per square inch gauge (psig) above that required by the capability curve between 0.5 and 15 psig (2 psig between 15 and 30 psig). The cold-gas temperature should not exceed approximately 46 degrees centigrade.

In order to protect the generator rotor against excessive heating in the event of loss of field excitation, it is becoming more common practice to install loss-of-field relays to either sound an alarm or trip the machine. Other relays are usually installed to detect grounds in the field excitation circuit, grounds in the generator armature circuit, and differential phase currents. Harmonic voltages and currents are present to a greater or lesser degree in all turbine generators, and it is helpful to know about the presence and effects of these harmonics in operating the machine.

A well-planned maintenance program, strictly adhered to, can greatly increase the reliability of the unit, lessen the number of unscheduled shutdowns, and help prevent outages of long duration. The maintenance program should not only consist of cleaning and replacing parts, but should include as an essential part of the program the setting up and maintaining of test records and inspection records. A review of these records before a scheduled shutdown may be very valuable in determining the work to be done.

Those parts of the generator which require frequent checking or adjusting are made readily accessible. Collector and exciter brushes, collector rings, and exciter commutators should be checked frequently. Dirty filters in the collector or exciter ventilation circuits are almost certain to cause trouble due to restricting the ventilating air and allowing the passing of abrasive dust. Neglecting brush maintenance is a frequent cause of troubles.

Under proper operating conditions a complete inspection of the generator is required at infrequent intervals only.

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A New Technology of Insulating Oils of Petroleum Origin

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New theories concerning the structure of oil and the behavior of some of its basic constituents are explained in simplified terms. Their application to the requirements of the insulating oil problem is discussed.

A NEW TECHNOLOGY of insulating oils of petroleum origin has evolved from theories based on a long-time study of oils under power-system operating service conditions. This study has already resulted in the concept, recently published,[1,2] that insulating oils when properly serviced and treated with additives can be given practically unlimited extension of useful life, free from sludge or excessive acidity caused by oxidation. An extension of the study to refining processes has now led to new practical theories concerning the structure of oil and the behavior of some of its basic constituents. Accelerated tests that are a measure of the quality of an oil in terms of useful operating life characteristics are an indispensable tool in the new technology.

This article outlines these theories and their application to the requirements of the insulating-oil problem. It indicates possible improvements in current refining practice and provides a means for evaluating new refining methods for producing oils adequate for present-day applications. It furnishes a groundwork for the study of special new types of insulating oils designed to meet added requirements that are being imposed by advanced designs of electrical equipment.

BASIC CONSIDERATIONS

THE REQUIREMENTS for new oils in new apparatus have been slowly changing and there has been a growing trend which involves three basic changes in oil philosophy, namely:

1. Greater importance is being placed on the life period of oils containing only natural inhibitors in apparatus in service before the first significant appearance of deteriorated oil products, as opposed to the older philosophy of emphasizing the rate of growth of deterioration products in oil after they have appeared.

2. Present-day oils may not be the optimum, either economically or technically, which can be obtained with present crudes and refinery facilities when evaluated under the philosophy expressed in basic change 1.

3. Growing trend toward using less oil in power apparatus, higher over-all thermal conditions, and possibly higher maximum stresses in future designs may easily require more fundamental knowledge and possibly new types of oil. Today and in the future more than ever the oil is an integral part of the dielectric rather than just a cooling medium.

Although the subject matter of this article applies to insulating oils of petroleum origin in general, for the purpose of explanation, one particular type of insulating oil known as transformer oil will be considered.

HISTORY

IN GENERAL, transformer oil is refined from a narrow cut or fraction taken overhead from the distillation of a carefully selected crude. Such a cut from the crude, normally referred to as raw distillate, is considered to have three main constituents with which this discussion is mainly concerned, namely:

1. *Saturated hydrocarbons*—nonaromatic; the base oil—predominantly naphthenic
2. *Unsaturated hydrocarbons*—predominantly aromatics, including natural inhibitors and stabilizers
3. *Corrosives*—including contaminants

Corrosives and contaminants that are present in varying amounts in different distillates must be removed as completely as possible in the refining process.

Since the early 1920's, good transformer oils have a primary-base portion, composed of saturated hydrocarbons of a predominantly naphthenic character, as compared to the predominantly paraffinic base of insulating oils before that date. The base portion is highly unstable by itself and becomes stable and unaffected by oxidation deterioration only when aromatics are present as a protection. It is known that in the absence of such aromatic protection the base becomes very unstable, and under oxidation it forms deterioration products of a more corrosive nature than those formed by similar deterioration of the oil when aromatics are present.

It is well recognized that some aromatic constituents in an oil have important effects on its useful life behavior. It is probable that every acceptable oil contains both good and bad aromatics in terms of its operating characteristics as an electrical insulating and cooling medium.

However, although it is agreed that valuable aromatics are unsaturates, nevertheless the art considers unsaturates in general to be undesirable. It has been the practice in the refining process to arbitrarily reduce the over-all quantity

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of the unsaturates in an insulating oil, with perhaps insufficient regard to the fact that desirable constituents may be destroyed.

A complication in the study of aromatics, as found in an oil, is the fact that so far it is not possible readily to separate or isolate the good from the bad aromatics, partly because they are closely allied chemically and may have practically the same boiling range.

OIL STRUCTURE AND BEHAVIOR

So as to better discuss new theories applicable to this problem, it is desirable to have a terminology that can be understood by the operating engineer, as well as by the research chemist. Inasmuch as the physics and chemistry of oil are extremely complex, an attempt has been made to furnish a set of simple terms and diagrams to act as a vehicle for purposes of study and analysis. This has had general acceptance, and already its use has contributed to a better understanding of some of the basic principles involved in oil technology.

Letter symbols are assigned to various types of oil constituents having differing qualities as shown in Fig. 1 and Table I. Referring to Table I, it can be seen that the aromatics which are believed to act favorably as natural inhibitors or stabilizers are referred to as *A*'s and *B*'s, whereas the corrosives or other undesirable constituents which can and must be removed from the oil are designated as *X*'s, *Y*'s, and *Z*'s.

In addition to these elements, there are known to be present certain constituents which have undesirable reactions on the *A*'s and *B*'s but having similar boiling ranges and, perhaps, being chemically allied to the *A*'s and *B*'s, their separation and removal so far has not been possible. This type of undesirable element which acts as a catalyst or negative inhibitor is called *N*.

It is possible that the total *A–B–N* content is a comparatively small part of the total aromatic content and the remainder of the aromatics, perhaps up to a considerable percentage of the total aromatics, may be relatively inactive as far as *A–B* action is concerned. This group of relatively inactive aromatic unsaturates is called *I*. It is possible that this division of the aromatics previously has not been well understood.

The relative amounts of the *A–B–N* and *X–Y–Z* constituents are of extreme importance in the selection of crudes suitable for refining into transformer oil. Already the choice of crudes is affected by the pour point and other considerations which limit the available crudes to less than 3 per cent of the total. A further limitation for the crudes proper for transformer oil may come from a better knowledge of the ratio of *X–Y–Z*'s and the *A*'s and *B*'s.

Where the ratio of the *X–Y–Z*'s to the *A*'s and *B*'s is too high, most of the natural protective unsaturates may be lost in the required removal of *X–Y–Z*'s during refining, leaving the base element *P* unprotected. Similarly, where the *A–B* vs *N* ratio is unfavorable, the protective effects of the *A–B* constituents may be cancelled by the action of the *N* elements, so that the over-all quantity of unsaturates will have to be reduced to a lower level. However, in crudes where there is a preponderance of *A–B* constituents over

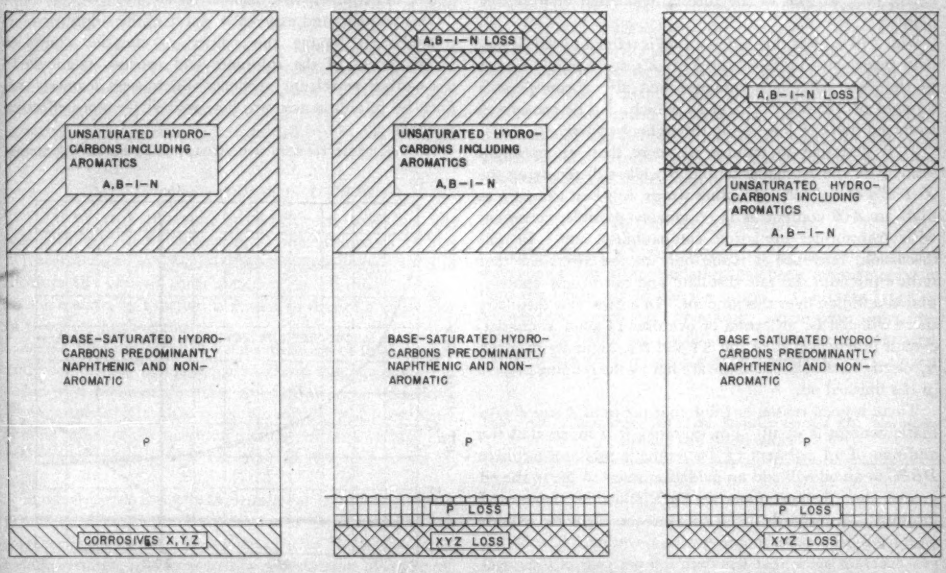

Fig. 1 (left). Constituents of transformer-oil distillate. Fig. 2 (center). Optimum refining of transformer-oil distillate. Fig. 3 (right). Overrefining of transformer-oil distillate.

Table I. Symbols for Constituents of Transformer Oil Distillate

Symbol	Quality	Nature	Characteristics
A	Good	Unsaturated natural inhibitor—aromatic	Resistance to oxidation
B	Good	Unsaturated natural stabilizer—aromatic	Resistance to liberation of gases
I	Innocuous	Unsaturated relatively inactive aromatic	A large percentage of total aromatics
N	Bad	Unsaturated catalyst—negative inhibitor	Linked inseparably to *A* and *B*
P	Good	Saturated base constituent of oil predominantly naphthenic nonaromatic	Stable only when protected by *A* and *B*
X	Bad	Corrosive nature	Must be removed by refining
Y	Bad	Corrosive oxidation inhibitor	Must be removed by refining
Z	Bad	Contaminant	Must be removed by refining

NOTE: The table refers to certain oil constituents by classification. It should be recognized, however, that a very practical consideration is concerned with the over-all solvency powers of an oil in contact with a variety of solid insulations. These solvency powers, which may be imparted to an oil predominantly by the unsaturated constituents in the table shown as *A*'s, *B*'s, *I*'s, and *N*'s, must be carefully considered in the final analysis of the acceptability of an oil.

N's, the over-all quantity of unsaturates should be kept at the highest level possible consistent with compatibility.

OPTIMUM REFINING

THE DESIRED PRODUCT in the refining of an oil is one that has been completely freed from corrosives and contaminants, has the longest possible useful life as an insulant and a coolant, and is compatible with the solid insulating materials with which it is in contact.

For purposes of illustration, examples of refining by a typical sulphuric-acid method will be shown. The method includes neutralizing, water washing, finishing with fuller's earth, etc., as well as the direct application of sulphuric acid.

Fig. 2 illustrates that when an oil is refined by sulphuric-acid treatment to remove the *X*–*Y*–*Z*'s, some small amount of the base portion is removed and also a considerable amount of *A*'s, *B*'s, *N*'s, and *I*'s, which may be considered as mixed more or less evenly throughout the oil.

It is desirable to remove no more than an optimum amount of the aromatics *A* and *B* while still removing the *X*–*Y*–*Z*'s completely. In other words, it is best to retain as high an *A*–*B* content as is reasonably possible, consistent with transformer–insulation compatibility, etc. In this discussion, reference is made only to the aromatics that nature put into the raw distillate and not to any contemplated addition over this amount. In a good raw distillate, there will not be an excess or overdose of good aromatics, even if practically all of the *A*'s and *B*'s originally supplied by nature in the raw distillate are left by the refining process in the finished oil.

There is good reason to think that the total *A* and *B* aromatic content is small. For example, it is found that the addition of 0.1 per cent of the synthetic inhibitor additive *DBPC* to an oil will add an oxidation-resistant life to the oil greater than the corresponding life supplied by the natural inhibitor. As regards the *B* content, the capacitor experts who have been experimenting with a synthetic *B* or hydrogen acceptor show that less than 0.5 per cent of their synthetic *B* is entirely adequate to fortify a completely over-refined white oil with all the *B* action that is needed.[3]

In Fig. 2 is shown the amount of destruction of *A*'s and *B*'s that might accrue from an optimum sulphuric-acid-refining treatment.

OVERREFINING

IT IS BELIEVED that Fig. 3, which shows still greater loss of *A*'s and *B*'s, illustrates what actually may be taking place in some of the commercial sulphuric-acid-refining treatments because some sludge-test specifications apparently have forced the refiner to do extra refining. This reduces the *A*'s and *B*'s below the optimum amount assumed in Fig. 2.

It is an opinion that care should be taken so that the refiner can avoid the unnecessary removal of *A*'s and *B*'s, which takes place when an oil is refined beyond a minimum point that has been determined to be absolutely necessary to rid the oil of *X*–*Y*–*Z*'s and also to be compatible with solid insulation from a solvency standpoint. Although this premise holds true for any type of transformer-oil refining, it is particularly pertinent to sulphuric-acid refining, which up to now has been used for practically all of the accepted transformer oils.

OTHER REFINING CONSIDERATIONS

THE REMOVAL of good aromatics in the refining process occurs because the sulphuric acid is nonselective in its action and indiscriminately removes or destroys some desirable oil constituents along with the unwanted corrosives and contaminants. In the process of removing both good and bad constituents of the oil, the refining treatment forms sulphuric-acid sludge, which is unfit for any practical use and is an extremely bad disposal problem for the refiner.

This wasteful and expensive aspect of the sulphuric-acid treatment is forcing the refiner to consider complete abandonment of the sulphuric-acid process, particularly since other petroleum products which were formerly refined by sulphuric acid are now refined by more effective methods.

In fact, some refiners are already manufacturing trans-

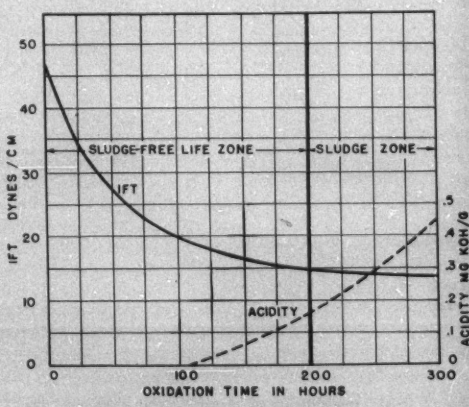

Fig. 4. Accelerated life test on new oil.

Table II. Comparison Accelerated Life Tests on Different New Transformer Oils

Currently Available New Oils	Hours of Sludge-Free Life by Accelerated Oxidation Test
1	197
2	180
3	119
4	150
5	61

former oil by other refining processes which, so far, have not produced acceptable products.

NEED FOR NEW TESTS

This situation poses the problem of analyzing new unknown types of oil by laboratory test methods, inasmuch as there is not sufficient time to get the operating experience which has been one of the principal criteria for judging the quality of a transformer oil in the past. There are American Society of Testing Materials (ASTM) standard tests that are intended to show when the *X–Y–Z*'s have been sufficiently removed from the oil. There are no ASTM standard tests that are adequate to indicate the optimum refinement of an oil in terms of *A–B* vs *N* reactions.

As previously noted, it appears that the art has a tendency to regard the finished oil as having only two main types of constituents—saturates and unsaturates—and to take the stand that the percentage of unsaturates should be kept to a low value.

It is felt that this attitude is not necessarily sound and may result in overrefining to reduce the amount of total unsaturates, including the good as well as the bad aromatics, in order to meet an arbitrary standard.

Two of the principal tests that currently are in use in this connection are the test for unsaturates and the sludge-accumulation test, both of which are dependent on total aromaticity rather than on the net effect of good and bad aromatics.

ACCELERATED OXIDATION TESTS

To meet this problem, an accelerated oxidation test was developed in the laboratory,[1,2] which evaluates the *A* vs *N* interactions even though it does not actually separate and measure the various constituents of the oil quantitatively. In some ways, its function is similar to that of a wattmeter in electrical measurements.

In a-c measurements, the determination of total current and voltage, may be inadequate to show average power because of a phase-angle difference between the quantities. The wattmeter is a phase-sensitive device, which evaluates the net effect of the magnitude of current and voltage and their phase relationship, resulting in the true power in watts.

Similarly, the over-all measurement of unsaturates or aromatics does not indicate the useful life of an oil. The oxidizer test does evaluate the net effect of the *A* vs *N* interaction, resulting in a measure of the sludge-free life of an oil.

Fig. 4 depicts the life characteristics of a new oil with no additive in terms of interfacial tension (IFT) and acidity during such an accelerated oxidation deterioration or life test conducted at 95 C.

Initially the oil has an IFT of 45-plus dynes and practically zero acidity. As the oil is subjected to contact with oxygen, either directly or as part of normal air, the IFT falls rapidly at first and then more gradually until sludge begins to form, usually at some point below 16 dynes. Meantime, the acidity values have an opposite trend. In general, practically no change is noted during the time when the IFT is descending rapidly and then there is only a gradual rise in the acidity as the IFT curve flattens out near the sludge point. The criteria for the test are the number of hours which elapse before the first appearance of sludge or a given acidity.

When this oxidation test is applied to different types of new oils with no additives currently available on the market, a considerable difference is noted in the indicated useful sludge-free life of the oils, as shown in Table II.

Operating experience has indicated that these variations in the sludge-free life, as shown by the test, are significant and a reliable index of important differences in the quality of the oils. In Table II, the first four oils having high values are accepted high-grade oils.

Table III shows a comparison of the results of this test with sludge accumulation and per-cent unsaturate tests on Oil 1 of Table I and the same oil additionally refined.

It will be noted from Table II that Oil 1 has the longest laboratory sludge-free life of any of the good new oils tested. Years of operating experience have proved this oil to be one of the best on the market. The refiner was forced to overrefine this oil to meet a lower per cent of unsaturate value, which the purchaser considered indicative of a better oil. The refiner agreed that the overrefined oil was better because it had a lower sludge accumulation test value. The known good-operating experience with Oil 1 has proved it to be of excellent quality. The lower value of the oxidizer test for the overrefined oil shows that its operating life had been reduced and indicated that, in this case, the reduction in per cent of unsaturates and the reduced sludge-accumulation test were not indications of a better oil.

FUTURE REQUIREMENTS

In the design of transformers up to the present time, the resistance of an oil to oxidation has been more important than the resistance to gas formation. The early types of transformers were free breathing, which represents the most severe oxidation condition. Although this situation has been improved by sealing of transformers, this may not

Table III. Comparison of Test Results on an Oil Normally Refined and Overrefined

Oil	Hours of Sludge-Free Life by Accelerated Oxidation Test	Per-Cent Unsaturates	Sludge Accumulation		
			3 Days	7 Days	14 Days
1	197	18–19	0.077	0.161	0.250
1 (Additional refinement)	122	16.5	0.051	0.111	0.182

completely solve the problem and resistance to oxidation will continue to be important in the design of an oil.

In the future transformer, the resistance to formation of gases will be increasingly important because requirements may approach those of cables and capacitors where electric stresses on the oil are such as to promote gas formation.

The development of oxidation inhibitors[1,2] has made it possible to control the oxidation characteristics of an oil. Unfortunately, this type of additive that apparently supplements the natural inhibitor *A* (oxidation resistance) does not similarly supplement the natural inhibitor *B* (resistance to gassing tendencies). For this reason, when an oil has been overrefined or deteriorated in service, the addition of an oxidation inhibitor restores the oxidation resistance but does not restore resistance to gassing.

Inasmuch as both oxidation resistance and gassing resistance may be required in the oils of the future, it is believed that the refining of an oil should be so regulated that a maximum amount of *A*'s and *B*'s are left in the oil so that the addition of an oxidation inhibitor will supplement the oxidation resistance and hold the existing gassing resistance.

Unfortunately, there is a tendency, perhaps through misunderstanding, to doctor a badly overrefined oil or one deficient in natural inhibitors by the simple addition of an oxidation inhibitor. This is an incomplete and insufficient cure resulting in an unsatisfactory oil, which is difficult to analyze by the oxidation test. For this reason, basic studies of new oils must be made on the oil without additives.

Another vital requirement for new types of oils arises from the growing trend to replace the sulphuric-acid refining treatment by which practically all our present oils are made. These oils have been designed around years of operating experience and their evaluation by test depends somewhat on continuity of this background of experience. Admittedly the present list of accepted tests is inadequate to insure an oil having all the desired characteristics. New tests are needed to form the basis for a specification that will guarantee the qualities desired, particularly in a new oil.

The need for such new tests is further emphasized by the greater demands being made on the oil by the use in modern design of less oil, higher thermal loading, and increased electrical stresses. These considerations place new responsibilities upon the engineers and chemists of the electric equipment manufacturer and power group to write a specification for oil that will enable the oil refiner to meet the new requirements.

TESTS

THE NEW TESTS required may well include such tests as:

1. *To Indicate Total Unsaturates in an Oil.*
   1. Specific optical dispersion.
   2. Sulphuric-acid absorption.
   3. Aniline point.
2. *To Measure Natural Inhibitor, A—Resistance to Oxidation.*
   1. Accelerated oxidation test at 95 C.
   2. Rotary bomb.
3. *To Measure Synthetic Inhibitor Response or Susceptibility* (Same apparatus as under 2).
4. *To Measure Natural Inhibitor, B—Hydrogen Acceptance.* Tests of the Pirelli type to evaluate gassing tendencies or hydrogen acceptance.
5. *To Measure Compatibility of Oil and Transformer Materials.*
   1. Peroxide number on oil.
   2. Mechanical strength of solid insulation exposed to oil.
   3. Solubility tests for interaction of oil with transformer materials.
6. *Impulse Strength.*
   1. Oil alone.
   2. Oil in combination with solid insulation.

In addition to the foregoing tests, attention should be given to detailed refining methods and techniques and, if the oil is to meet the requirements of the power art for a universal oil, to its arc-quenching and carbon-formation characteristics.

SUMMARY

CHANGING REQUIREMENTS for new oils imposed by progress in apparatus design are bringing about three main changes in oil philosophy:

1. More importance is being placed on the life period of an oil before sludging occurs.
2. Studies of this period show that better oils may be obtained with present crudes by changes in present refining processes.
3. Increasing demands on oil as a dielectric and coolant will require more fundamental knowledge and new types of oil.

New theories of oil structure and behavior, based on studies of oils under operating service conditions, are explained in simplified terms and their application in developing a new oil technology is outlined. Fallacies in present practice are described in the light of the new theories, and the parts played by the various oil constituents in determining oil behavior are clarified. The importance of a proper understanding of the functions of these constituents and the need for new standard tests to investigate them and for control of refining processes is emphasized.

The use of accelerated life tests in the study of this situation is described. The problem posed by the trend towards abandonment of the sulphuric-acid refining process by which most accepted oils have been produced is discussed, and the application of accelerated life tests to this problem of evaluating new oils of unknown background with no previous history of operating experience is explored. Other tests of possible value in such an investigation are listed, and the need for proper specifications to guide the oil refiner is explained.

CONCLUSIONS

SERIOUS PROBLEMS in connection with insulating oils of petroleum origin have been developing for some years. Investigation of these problems has resulted in a new concept and new theories which contribute to a better understanding of oil structure and behavior. Operating experi-

ence has proved the new concept to be sound. Analysis of service data correlated with laboratory tests has substantiated the new theories. These theories have a general acceptance by authorities representing the electric-power group, equipment manufacturer, and the oil refiner. A new test approach to some of the vital problems furnishes valuable data for an analysis of chemical and physical phenomena that has not been possible by accepted standard tests currently in use. It appears that these new developments in oil technology make possible a new era in the design, manufacture, and operation of insulating oil.

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3. Gassing of Liquid Dielectrics under Electrical Stress, **Harold Basseches, D. A. McLean.** *Industrial and Engineering Chemistry*, Easton, Pa., September 1955, Pt. 1.

COMMENTS

F. M. Clark (General Electric Company, Schenectady, N. Y.): I have read Mr. Doble's paper with great interest because of the work which my associates and I have done in this field in the past.[1] I am particularly delighted that Mr. Doble's present researches and concepts agree so well with our earlier conclusions.

For example, Mr. Raab and I say that: (1) A common danger is overrefining, since the initial properties of an oil improve by exhaustive treatment, whereas the dielectric stability reaches a maximum with oil-refining treatment, beyond which further oil refining produces increased instability. (2) The object of the refining treatment is to eliminate as completely as possible the olefin type of unsaturation without severe reduction in the aromatic type of unsaturation. For one type of distillate oil, this preferred aromatic hydrocarbon content was found to be 22 to 23 per cent, corresponding to a specific optical dispersion value of 115 to 117.

There are numerous points of similarity in the conclusions of these papers by Mr. Doble and by Mr. Raab and myself. I conceive that the obnoxious olefin unsaturated hydrocarbons and the obnoxiously excessive amount of aromatic unsaturated hydrocarbons of our paper find their counterparts in Mr. Doble's classifications.

I want to congratulate Mr. Doble on the emphasis which he places on the problem of petroleum technology. Industrial requirements and industrial concepts of oil quality are continuously changing. Because these changes may and generally do greatly affect the selection and refining treatment of the insulating oil, Mr. Doble's engineering analysis of an important, but difficult material problem, cannot help but be of assistance to the petroleum technologist working in this field.

E. L. Rabb (General Electric Company, Pittsfield, Mass.): Mr. Doble is to be congratulated for calling attention to certain trends in the refining and usage of transformer oil which, we believe, call for a critical re-evaluation of our present and future needs both in terms of quality and quantity. As of now, the better transformer oils available are considered to be entirely adequate, qualitywise, for today's needs when properly handled and maintained. This will probably also be true for the immediate future. This does not mean, however, that we might not be able to use a better quality oil advantageously now, and possibly a better quality oil may be highly desirable in the future. It is certainly of interest to note that at least three separate trends are simultaneously involved, each of which could affect the quality and quantity, or both, of available transformer oil. The increasing utility emphasis on the first practical appearance of deterioration products, rather than the older "rate-of-deterioration" basis, immediately raises the question as to whether today's oil is refined to the optimum degree to fit these new criteria. Certainly the desire of refiners to get away from acid refining for a variety of reasons not only raises questions of quality, but also of available quantity. The third trend is the designer's desire to utilize oil to a greater degree as a dielectric medium by subjecting it to greater electrical stress and higher overall temperature conditions. Thus, we have the utilities, the refiners, and the transformer designer indicating certain evolutionary changes in the field of transformer oil.

As Mr. Doble points out in his paper, the terminology has been purposely oversimplified in order that all three areas affected can have a common meeting ground. The working hypothesis proposed offers an approach to this problem which, if successful, could satisfy the needs and desires of the ultimate user, the refiner, and the transformer designer.

C. A. Duke (Tennessee Valley Authority, Chattanooga, Tenn.): The author has presented a very good summation of a complex subject. We, as users of oil, are particularly interested in obtaining a product that has not had valuable properties removed by overrefining, which possibility is pointed out in the paper. We are in accord with the general points in the paper, and over the years have patterned our tests and specifications along the same line of reasoning as that of the author.

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European Power Line

Electricité de France (EDF)'s new power line to connect Paris, France, with the production centers in the Alps will almost double the present tension to 420,000 volts. Circuit breakers for the new line will contain a small quantity of oil, and will have a capacity of 12 million kv. They will be built by the Ateliers de Constructions Electriques de Delle (Compagnie Général d'Electricité), which has done similar work for the world's first 400,000-volt power line in Sweden.

Another branch of the Compagnie Générale d'Electricité, the Savoisienne (Ateliers de Construction de Transformateurs) has received an order for 4 single-phased autotransformers, with each unit weighing over 150 tons.

The Unfinished Business of Engineering Ethics

P. L. ALGER
FELLOW AIEE

In view of the engineer's expanding role in our modern world, he must be prepared to accept the added professional responsibilities. Thus, it is the consensus of opinion that several supplements be made to the Canons of Ethics of the Engineers Council for Professional Development.

THE ENGINEER'S WORK is continually expanding. Every step forward in automation, regional planning, or industrial organization widens the circle of those with whom the engineer must work in harmony and, also, the circle of those affected by his work. To fill this expanding role, the engineer must have greater understanding, more sympathy, and higher skill in dealing with people, as well as greater technical knowledge.

As the scope of his work expands, the engineer must weigh more carefully the values that are concerned in his decisions—comparing the benefit with the cost, and considering both how the benefits should be distributed and how the costs should be assessed.

In order for the engineer to do all this in a manner that will be a credit to the dignity and honor of his profession, he must maintain high ethical standards. The Engineers Council for Professional Development (ECPD) Canons of Ethics, as well as the separate ethical codes of the engineering societies provide rules of conduct, but these are not as specific or complete as can be desired. It is proposed, therefore, that the ECPD and associated engineering societies undertake a modernization of their separate codes, together with the preparation of several supplements to the Canons, that will more fully cover the widening scope of the engineer's work.

IMPORTANCE OF ETHICS TO ENGINEERS

HISTORICALLY, there have been two kinds of ethics: one prescribes the relations within the family or clan, and the other deals with relations with outsiders. The first kind of ethics has always been more unselfish than the second. With the growing complexity and lengthening time scales of production and distribution processes, as caused by the ever greater division of labor, the size of the group to which the more unselfish kind of ethics applies has steadily increased. Everyone now agrees that the "public" good must be given high weight in deciding what is right to do in any given case. Just who are included under the term "public" is still debated, but more people are being counted in all the time.

The larger the clan membership, the more unselfish the code of ethics must become for the individual. Thus, the breadth of application and the character of ethical codes are not fixed, but must change with the times.

In earlier times, a man who abstained from sin was called a "good" man. An ordinary person, not an engineer or scientist, may be held to deserve moral admiration even if he has never performed a single generous act. This is in keeping with the negative spirit of most moral codes and the civil law, that are designed merely to prevent wrongdoing. Engineers and members of the other professions are expected to go beyond this objective by living up to a positive code of ethics. In gaining an education, a lifetime debt to society is incurred, since the costs of a professional education are far greater than the tuition payments. The first duty of an educated man is to repay this debt through unselfish service to the community and by contributing to the education of his juniors.

"Right" as opposed to "wrong" is a concept connected with power, and has to do with the acts of those who are not constrained to obey others. Kings should "do right in the sight of the Lord." Some of this kind of positive duty is inherent in every kind of office or profession and, indeed, in every position that confers either power or freedom of action. Soldiers must fight, firemen and coast guards must risk their lives to save others, doctors must risk infection, and parents must provide for their children. Every member of the clan is in debt for the amenities of living that are provided by society as a whole, and each has a corresponding duty to perform community services in return, which is over and above the mere payment of taxes.

Each right or each freedom, that has been won in the centuries of human progress, has brought with it a corresponding duty. In modern terms, every manager has, or should have, a responsibility matching his authority. Thus, each profession has come to have its own ethical code, which is more precise in some respects than the ordinary moral code and much more positive. Doctors are bound by the Hippocratic oath, soldiers by military rules, the clergy by Canon law, and the gentleman by his code of honor.

ENGINEERING PROFESSION

THE ENGINEERING PROFESSION has a unique role in the modern world, because the engineer is the central figure in the complex procedures of mining, transporting, manufacturing, and building on which civilization rests. At

Full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956, and recommended for publication by the AIEE Committee on Code of Principles of Professional Conduct.

P. L. Alger, Chairman of the AIEE Committee on Code of Principles of Professional Conduct, is with General Electric Company, Schenectady, N. Y.

present, the engineer is called upon to share in planning, managing, and promoting projects of every sort that depend on technical skill for their accomplishment—and what large-scale project nowadays does not call for technical skill? The engineer requires a broad knowledge of economics, history, and the forces that sway the minds of men, if he is to fulfill his expanding role—and, equally, he must behave more and more unselfishly in accordance with his expanding role. As a logical sequence, the subject of ethics is an unfinished business.

The techniques of science are the only elements of modern culture that remain truly international. In religion, law, ideals, education, and customs of every sort, the Iron and Bamboo Curtains divide the world into two opposing camps. However, the scientist or engineer who passes from one side to the other finds the laboratories, tools, and methods all familiar. So long as they confine themselves to scientific techniques, men from the two sides may converse without disagreement. Science, itself, is amoral—but those who use science may be either ethical or unethical, and any ideas exchanged usually convey ethical concepts by contagion, if not directly. Slender as it is, this remaining bridge of common understanding may have an important influence on the thinking on both sides of the curtain.

Thus, more and more trust is being placed in engineers by their employers, their associates, and the public. Every engineer should be prepared to accept the corresponding responsibilities, and to fulfill them in a manner that will do credit to the dignity and the honor of his profession.

CANONS OF ETHICS FOR ENGINEERS

THE DEVELOPMENT of ethical codes for engineers has been going on for a great many years. About 8 years ago, the ECPD formally adopted the 28 Canons of Ethics that appear in the AIEE *Year Book*, and these have now been accepted by 82 different engineering organizations. At the meeting of the ECPD in Toronto, Ont., Canada, October 1955, the Canons were reviewed, and the whole area of professional ethics was discussed at great length. The consensus was that the task of creating an adequate code of engineering ethics is far from completed.

The 28 Canons are sound and clearly stated. They provide basic rules for the professional life of the engineer, as well as for his relations with the public, employers, and other engineers, which every engineer should know and live up to. No one at the Toronto meeting questioned the soundness of these basic rules or proposed to alter them. However, it was recognized that in some areas the Canons are not sufficiently complete or specific enough to meet present-day conditions.

Each of the major engineering societies has its own code of ethics, which supplements the Canons of the ECPD. A review of these supplementary codes reveals striking differences and also wide areas not adequately covered. This is natural, as the human relationships that are most important and sensitive are different in each branch of engineering. As their work expands, engineers will often find the codes of other branches very helpful in meeting many new responsibilities.

It has been proposed, therefore, that the different engineering codes be collected or summarized in a pamphlet and, thus, made widely available, perhaps by the National Society of Professional Engineers. On the basis of all these factors, also, it was the consensus of the ECPD Meeting at Toronto that several supplements to the ECPD Canons should be developed.

PROPOSED SUPPLEMENTS TO THE CANONS

IT WAS PROPOSED that, after suitable consideration is given to developing the supplements with the help of committees from the different engineering societies, the ECPD Committee on Ethics should prepare and distribute pamphlets supplementing the Canons in several distinct areas. These suggested supplements are:

1. *Ethics for Employers of Engineers (Supplementing Numbers 21 and 22 of the Canons).* This should emphasize the truth that the engineer has a personal responsibility for his professional work, which cannot be delegated to others; it should make clear the distinction between the work of the engineer and of the technician. Also, the duty of employers to provide opportunities for each engineer to extend his education and to contribute to professional society activities should be made clear.

2. *Ethics for Engineers Who Work for More Than One Employer (Supplementing Numbers 15 and 27 of the Canons).* The duty of the employed engineer to obtain the consent of his employer before undertaking work for another should be emphasized. Also, the engineer's obligation to give full measure of services to each employer or client, beyond the mere devotion of a specified time to the work, should be fully developed. This subject is important because of the large number of employed engineers who have "week end" jobs also, and because of the many engineers who divide their time between two or more employers.

3. *Ethics of Recruiting.* This may well be based on the pamphlet recently prepared by the American Society for Engineering Education (ASEE) on this topic. It should give special consideration to the procedures in recruiting college students, and to the practice known as "pirating" of already employed engineers. The proper procedure for an employed engineer in seeking a new position should also be developed.

4. *Ethics for Engineering Students.* This may well be based on the excellent pamphlet, *Engineering—A Discipline*, that has been used for some time in the Newark College of Engineering. It should give special consideration to the honor system in homework and examinations. It should make clear the responsibilities of students to their teachers and to the educational institution.

5. *Ethics for Licensed Professional Engineers (Supplementing Numbers 4, 11, 12, 17, and 28 of the Canons).* This should provide a specialized code of ethics that may be used by licensing boards in deciding whether to grant or to withdraw licenses. It should be so phrased that the ethical requirements set forth may be legally enforceable, and that ultimately it may form a number of supplements to the Model Licensing Law.

6. Ethics for Engineering Organizations. This should make clear the duty of the engineer to put the interests of the public before personal gain and should outline what are fair and proper procedures for engineering organizations in their relations with employers, other similar organizations, and the public.

THE TEACHING OF ETHICS

THE IMPORTANCE OF ETHICS in the professional career of the engineer is so great that it is highly desirable to include the subject in undergraduate teaching. It was the consensus of the ECPD group at Toronto, and especially of the ASEE members, that the ethics of students reflect to a large degree the examples set by their teachers and by the members of the profession with whom they come in contact. It was also their considered opinion that ethics should be taught by the case method, as law is, so that a book of ethical problems and their solutions, taken from real life, will be extremely useful to educators. With this purpose in mind, the AIEE Committee on Ethics proposes to collect material of this kind, and to co-operate with the ECPD Ethics Committee in adapting it to teaching purposes.

REFERENCES

1. The Philosophy of Codes of Ethics, L. L. Fuller, *Electrical Engineering*, vol. 74, no. 10, October 1955, pp. 916–8.
2. Human Society in Ethics and Politics (book), Bertrand Russell, Simon and Schuster, Inc., New York, N. Y., 1955.

The Magnetic Fields of Isolated Moving Charges

H. L. ARMSTRONG

THE AIM of electromagnetic theory is to investigate the properties of electromagnetic fields and relations to their sources. One problem in the latter category which is of some interest is that of determining the magnetic field due to a moving electric point charge. It is observed that the field is "proportional to the magnitude of the charge, its velocity, and the sine of the angle its velocity makes with the line joining it to the point of observation, and inversely proportional to the square of the distance from the charge to the point of observation." In vector notation, and rationalized Giorgi units, which will be used in this discussion, this is written concisely as[1]

$$\mathbf{H}=\frac{q}{4\pi}\,\mathbf{u}\times\frac{\mathbf{r}}{r^3} \tag{1}$$

$\mathbf{H}$ is the magnetic field intensity, q the electric charge, $\mathbf{u}$ its vector velocity, and $\mathbf{r}$ the vector distance from the charge to the point of observation; r is the absolute value of $\mathbf{r}$.

It should be possible to relate this to Maxwell's equation, which gives $\mathbf{H}$ in terms of $\mathbf{J}$, the current density, and the time derivative of $\mathbf{D}$, the electric displacement, by[2]

$$\nabla\times\mathbf{H}=\mathbf{J}+\frac{\partial\mathbf{D}}{\partial t} \tag{2}$$

Frequently the two formulas are related by considering that the moving charge represents an "element of current," such that $\int \mathbf{J}\,dV = q\mathbf{u}$, dV being an element of volume and the integral extending over the small volume to which q is confined. This interpretation makes no use of the term $\partial\mathbf{D}/\partial t$. However, for the charge q, it is known[3] that $\mathbf{D} = (q/4\pi)(\mathbf{r}/r^3)$ and, when it moves at a velocity $\mathbf{u}$, a straightforward calculation gives for the time derivative

$$\frac{\partial\mathbf{D}}{\partial t}=-\frac{q}{4\pi}\nabla[\mathbf{u}\cdot(\mathbf{r}/r^3)] \tag{3}$$

which, it would seem, should be taken into account in equation 2. Now it is a known vector identity that when (as is true here) $\mathbf{u}$ is not a function of the spatial co-ordinates[4]

$$\nabla[\mathbf{u}\cdot(\mathbf{r}/r^3)]=-\nabla[\mathbf{u}\,(\mathbf{r}/r^3)] \tag{4}$$

From equations 1, 3, and 4 is derived

$$\nabla\times\mathbf{H}=\frac{q}{4\pi}\nabla\times[\mathbf{u}\times(\mathbf{r}/r^3)]=-\frac{q}{4\pi}\nabla[\mathbf{u}\cdot(\mathbf{r}/r^3)]=\frac{\partial\mathbf{D}}{\partial t} \tag{5}$$

But this is just equation 2 with $\mathbf{J} = 0$. Thus, the magnetic field of the moving charge may be accounted for by the displacement term in Maxwell's equation, and there is no need to consider the charge as an "element of current." Indeed, the interpretation of the moving charge as an element of current, and neglect of the displacement term, would make $\nabla \times \mathbf{H} = 0$ everywhere except in the region actually occupied by the charge. However, a decomposition of the left-hand side of equation 4 gives,[5] in general

$$\nabla\times[\mathbf{u}\times(\mathbf{r}/r^3)]=-(\mathbf{u}/r^3)+3(\mathbf{u}\cdot\mathbf{r})(\mathbf{r}/r^5)\neq 0 \tag{6}$$

A special article recommended for publication by the AIEE Committee on Basic Sciences.

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Thus, the interpretation in terms of changing displacement seems to be preferable.

A similar remark may be made about the idea of the magnetic field due to an isolated current element. An isolated conductor element of vector length **ds** carrying a current I must, since charge is conserved at both ends, have associated with it an electric dipole of moment **m**, the time derivative of **m** being given by

$$\frac{\partial \mathbf{m}}{\partial t} = I\,\mathbf{dS} \tag{7}$$

Such a dipole would cause an electric displacement whose time derivative would be[6]

$$\frac{\partial \mathbf{D}}{\partial t} = -\frac{I}{4\pi}\nabla[\mathbf{dS}\cdot(\mathbf{r}/r^3)] \tag{8}$$

and this, being of the same form as equation 3, gives for **H**, by a discussion analogous to that following equation 3,

$$\mathbf{H} = \left(\frac{I}{4\pi}\right)\mathbf{dS}\times(\mathbf{r}/r^3) \tag{9}$$

so that the magnetic field attributed to the current element could equally well be ascribed to the changing displacement which must be associated with such an element. In a closed circuit, of course, there need be no accumulation of charge and, thus, no changing displacement. In this case, the magnetic effects must be ascribed to the current.

The conclusion to be drawn from this discussion is that any treatment of isolated current elements, or of moving charges, in which the effects of changing displacement are ignored, is somewhat inconsistent and could be risky. When a charge is changing position, or a dipole moment is changing, the magnetic field can be calculated from the changing electric displacement by Maxwell's equation. The concept of current, then, might be reserved for phenomena which produce magnetic effects but show no particle motion on a macroscopic scale. (Of course, any current is a flow of electrons or other charged particles, but this is on a microscopic scale, which lies outside the range of ordinary electromagnetic theory.) It would be logical, then, to define the current density by

$$\mathbf{J} = \nabla\times\mathbf{H} - \frac{\partial \mathbf{D}}{\partial t} \tag{10}$$

which, indeed, amounts to what is done when a steady current is measured with a galvanometer.

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1. Principles of Electricity and Electromagnetism (book), **G. P. Harnwell.** McGraw-Hill Book Company, New York, N. Y., second ed., 1949, pp. 311–12.
2. *Ibid.*, p. 344.
3. *Ibid.*, pp. 13 and 66.
4. Die Mathematischen Hilfsmittel des Physikers (book), **E. Madelung.** Julius Springer, Berlin, Germany, third ed., 1936, reprinted by Dover Publications, New York, N. Y., 1943, p. 118.
5. *Ibid.*, p. 119.
6. **G. P. Harnwell,** *op cit.*, pp. 16 and 62.

Closed-Circuit Television Aids Psychiatric Training

Closed-circuit television has a new job—helping to meet America's vital need for more psychiatrists. In what is believed the first closed-circuit project of its kind, the system produced by General Precision Laboratory, Inc. (GPL) of Pleasantville, N. Y., has been installed in the Nebraska Psychiatric Institute, Omaha, Neb. The Institute, under the direction of Dr. Cecil Wittson, uses the system to show advanced students actual treatment of patients by experts. At the Institute three cameras are used, each mounted with its control cabinet and monitor in a small cart, providing three completely mobile pick-up units. The camera is only 9 by 5½ inches and weighs five pounds. The chassis is the plug-in type, facilitating easy maintenance. Each treatment room has a separate camera port, through which the camerman can shoot without disturbing doctor or patient. The cameras are set up to cover up to three treatment rooms simultaneously. Because of the extreme sensitivity of the GPL camera, room lighting problems are minimized. The sound is picked up by microphones permanently installed in the ceiling of each treatment room. At the control room, the three pictures are monitored and the most significant treatment selected for transmission to the auditorium, where it is projected onto a screen by the GPL *PB-611* projector. Large groups of students are able to see and hear more clearly than if they were actually in the treatment room.

INSTITUTE ACTIVITIES

GOLDEN GATE BRIDGE, linking San Francisco with the rest of the Redwood Empire. The length of the main span of this great bridge is 4,200 feet The twin towers of the $35,000,000 structure are 746 feet high.

Redwood Empire Association Photo

Summer and Pacific Meeting Offers Comprehensive Technical and Social Program

THE AIEE 1956 Summer and Pacific General Meeting to be held in the Fairmont Hotel, San Francisco, Calif., June 25–29, will offer a program and activities that will appeal to all interests. A full and interesting technical program is assured. Six inspection trips of both general and technical interest climaxed by a sightseeing boat tour up the bay to the largest fuel-electric power plant west of the Mississippi will complete the program. Sports events will be highlighted by a salmon derby outside the Golden Gate. A diversified entertainment program for the ladies, and special activities for students round out the Convention schedule.

In addition to being host to the Convention, San Francisco is world famous as a vacation center. Places of historic interest and restful resort areas abound within easy driving distance. These features, combined with many other outstanding tourist attractions in northern California, offer an unequalled opportunity to combine a business trip to the Convention with a family vacation.

Registration

The registration desk will be located in the lobby of the Fairmont Hotel. Facilities for registering will be available Sunday afternoon, June 24, and continued throughout the meeting.

Members and nonmembers should register in advance by returning the advance registration card sent with the mailed announcement. Registration fees are $5 for members and $8 for nonmembers. Families and students will not be charged a fee.

Those registering are asked to indicate on the card the events in which they expect to participate. The San Francisco Section must make firm commitments and guarantees for several of the events prior to the start of the Convention. It is hoped that all persons interested in the various events can be accommodated, but to avoid disappointment advance payment of registration fees and ticket purchases is strongly recommended. Tickets will not be held unless prepaid. Remaining tickets will be sold after arrival at the Fairmont on a first-come first-served basis.

Social Activities

A Welcome Tea will be held at the Fairmont Hotel on Sunday, June 24, from 4:00 to 5:00 p.m. for early arrivals. On Tuesday, Wednesday, and Thursday, luncheons will feature outstanding speakers discussing various aspects of the growth of engineering in the West.

On Thursday evening, at the Fairmont Hotel, one of the highlights of the Convention will occur—the dinner dance with outstanding music and unusual entertainment. Dress for this event will be formal for the ladies, optional for the men.

Tickets for the luncheons will be $3.50 each; tickets for the dinner dance will be $10 per person.

Inspection Trips

A program of inspection trips of both technical and general interest has been arranged. Interested persons are urged to make arrangements at the inspection trips desk immediately after registering. People taking the inspection trips will be returned to the hotels in time for evening hospitality hours. Charges for transportation, etc., on the trips will be very moderate.

San Francisco Naval Shipyard (Tuesday morning, June 26). This tour of one of the most colorful and capable naval shipyards in the United States will include inspection of the submarine *USS Dentuda*, a tour of the waterfront with stops to view berthed ships, the drydocks, the world's mightiest crane, with a lift of 630 tons, and other points of interest as time allows.

United Airlines Maintenance Base and San Francisco International Airport (Tuesday afternoon, June 26). The San Francisco International Airport is the world's most modern passenger terminal. Located on the shores of San Francisco Bay, just a few miles from downtown San Francisco, it was completed in 1954 at a cost of more than $14 million. This 3,685 acre airport is one of the busiest in the world, serving the world's air traffic in the same manner that the world-famed harbor serves water-borne commerce and travel.

The United Air Lines Maintenance Base, located adjacent to the International Airport, is United's main repair center. On this

tour, complete facilities for renewing giant airliners, including extensive electric and instrument sections, will be seen.

University of California Radiation Laboratory (Tuesday evening, June 26). This evening inspection trip to the world famous radiation laboratories, at which the cyclotron was first developed, will feature the 120-inch Bevatron which is capable of accelerating protons to 6.2 billion electron volts.

Westinghouse Sunnyvale Plant and Ford Motor Company San Jose Assembly Plant (Wednesday all day, June 27). The Sunnyvale plant of the Westinghouse Electric Corporation is the most diversified in its output of any of the company's far-flung 51 major manufacturing plants. It manufactures everything from a quarter-inch gear, utilized in precision equipment helping astronomers to black out the sun for corona studies, to the world's largest rotating machine, a compressor now under construction, which will whip up Goliath gales in a wind tunnel for the U. S. Army Air Force. Among the other products Westinghouse manufactures in Sunnyvale are electric motors, transformers, panelboards, switchgear, 5,000 kw "packaged" power plants, valves, large air-moving equipment, gears, voltage regulators, and electric home heaters. The plant, which is the largest electrical manufacturing operation west of the Mississippi River, employs approximately 3,000 men and women.

The Ford Assembly Plant started production March 1, 1955. It has a potential capacity of 880 passenger cars and trucks daily on a two-shift basis. The plant contains 1 million square feet of manufacturing area, has 7 miles of conveyor system, and 250 miles of electric wiring. Approximately 3,000 people are employed at this plant. The group will lunch at the Ford Plant. After plant tours are completed, the group will return via the East Bay and San Francisco-Oakland Bay Bridge.

Ames Aeronautical Laboratory, Moffett Field, and Stanford University (Thursday all day, June 28). Ames Aeronautical Laboratory, established in 1940 at Moffett Field, is one of the three major research centers operated by the National Advisory Committee for Aeronautics (NACA). The primary role of Ames Laboratory is research in high-speed aerodynamics. Research equipment includes 19 major wind tunnels which are among the largest and fastest in the world.

After luncheon at Ames Laboratory, the group will move to Palo Alto for a tour of the Stanford University Campus. Here electronic facilities include a 200 inch electron linear accelerator, a new electron microscope which peers into the nucleus of the atom, and the famous Stanford Microwave Laboratory.

Pacific Gas and Electric Company's Steam-Electric Plant at Pittsburg (Friday all day, June 29). The men and ladies will join forces for this sight seeing boat trip which should be one of the highlights of the Convention. The trip will offer views of many points of interest in San Francisco Bay, including both big bridges and the near-completed Richmond-San Rafael bridge, four oil refineries, numerous industrial installations, and points of historical interest. The trip will terminate at the Pacific Gas and Electric Company's 660,000 kw Pittsburg steam-electric plant, the largest such plant west of the Mississippi. Tickets for this tour will be $4.50. Lunch and other refreshments will be available on the boat at a modest price.

Student Activities

In addition to other Convention activities, several events have been planned especially for students. An inspection trip to the University of California Radiation Laboratory is planned for Tuesday morning. In the afternoon the Undergraduate Student Prize Paper Contest will be held. A Counselors and Students Dinner at the International House, University of California, will take place Tuesday evening. Tickets for this dinner will be $2.65 each.

Thursday morning will see the Student Paper Presentations. At Thursday's luncheon the prize paper winners from all AIEE districts will be presented.

Ladies Entertainment Program

The ladies attending the Convention are sure to enjoy a full and diversified program. The Ladies Entertainment Committee, headed by Mrs. J. S. Moulton, has planned a wide variety of events that will appeal to all interests. Each day, Monday through Thursday, a hospitality room will be open in the Garden Room of the Fairmont Hotel from 9:00 a.m. to 5:00 p.m. as a meeting place and for cards. Coffee will be served from 9:00 to 10:00 a.m.

On Sunday, June 24, a Welcome Tea will be held at the Fairmont from 4:00 to 5:00 p.m. Monday will be free for individual shopping and sight seeing. Tuesday will feature a luncheon and fashion show at the Sheraton-Palace Hotel. A bus trip down the San Francisco Peninsula and a tour of the world famous Roth Gardens will occupy Wednesday morning followed by lunch at Rickey's Studio Inn at Palo Alto, and a stop at Sunset House during the return trip to San Francisco. On Thursday, a tour and shopping trip to Chinatown, the largest such settlement in the world outside China, and lunch, Japanese style, at Yamato's Restaurant will climax the separate activities planned for the ladies.

Women are cordially invited to play golf Tuesday morning, June 26. If a sufficient number play, a tournament may be arranged. Women may participate in the Salmon Derby on Wednesday. For the Thursday night banquet and dance, dress will be formal for the ladies, optional for the men. On Friday, the ladies will join the men on the sight-seeing boat trip up the bay to the Pittsburg Steam Plant.

At the time of the Convention the weather in San Francisco will probably be quite cool; Fall-type clothing is recommended. Baby sitting service will be available.

Tickets for the fashion show lunch will be $3.50. Tickets for the Peninsula tour and lunch, including transportation, will be $5.25.

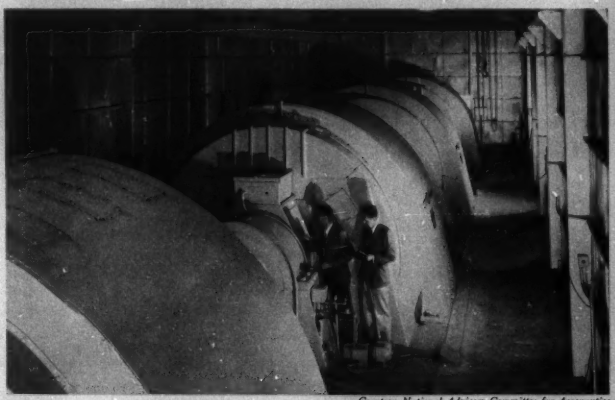
Sports

Golf. Lake Merced Golf and Country Club in San Francisco, beautifully situated with even terrain, will be host to all meeting registrants for a tournament commencing at 12 noon on Tuesday, June 26. Registered male members of Districts 8 and 9 (Pacific Coast members) may compete for the John B. Fisken Cup, a perpetual trophy. This cup is awarded for low net score—18 holes medal play. Several other beautiful and valuable prizes will be open to all players. Entrance fee is $5 per person, not including caddy. Caddies and carts will be available. Those interested are asked to bring their own clubs, but if they cannot, the Committee will be as helpful as possible in arranging for equipment. Lunch can be obtained at the Club prior to start of play.

The women of the meeting are cordially invited to play the same course early Tuesday morning, June 26. It is hoped that a sufficient number will play to warrant a tournament with prizes for the ladies.

Golfers should register at the Sports Information Desk for starting time and transportation, if desired. Club handicaps or

(*Continued on page 562*)



Courtesy National Advisory Committee for Aeronautics

INTERIOR VIEW of motor house of the Ames Unitary Plan Wind Tunnel, Ames Aeronautical Laboratory, Moffett Field, Calif., showing the four giant 45,000-hp electric motors which form the main drive of the wind tunnel.

Tentative Technical Program Summer and Pacific General Meeting, San Francisco, Calif., June 25-29, 1956

Monday, June 25

9:00 a.m. Relays

CP.* New Relaying Developments. *R. E. Cordray*, General Electric Company

CP.* A Transistorized Distance Relay. *F. R. Bergseth*, University of Washington

CP56-632. The Protection of Pilot Wire Relay Circuits. *Pacific Coast Subcommittee*

CP.* Tests and Operating Experience with Carrier Transfer Trip Relaying for Line Protection. *A. W. Adams*, Bonneville Power Administration

CP56-632. Protecting A-C Motors with Low-Voltage Air Circuit Breaker Series Trips. *F. P. Brightman, P. J. Reifschneider, R. R. McGee*, General Electric Co.

9:00 a.m. Substations

56-706. Present Practices in Electrical and Mechanical Design of Busses for Extra High Voltage Substations. *Working Group on Project* 53.1

CP56-707. Flexible Copper Braid for Electrical Buses and Connectors. *M. Brewer*, Penn Union Electric Co.

56-647. Basic Designs for Large High Voltage Substations. *E. G. Norell*, Sargent and Lundy

9:00 a.m. Instruments and Measurements

CP56-794. VIAC: A Variable Interval Automation Controller. *J. R. Wood, M. L. Klein, H. C. Morgan*, North American Aviation Inc.

CP56-795. Accurate Measurement of Phase Shift at Low Audio Frequencies. *W. M. Meier*, Westinghouse Electric Corporation

9:00 a.m. General Industry Applications

9:00 a.m. Communication Theory

CP56-653. The Communication Engineer's Needs in Information Theory. *W. T. Ree*, Bell Telephone Laboratories, Inc.

CP.* Reliable Circuits Using Less Reliable Relays. *E. F. Moore, C. E. Shannon*, Bell Telephone Laboratories, Inc.

CP.* What Use Is Delta Modulation to the Transmission Engineer? *F. K. Bowers*, Bell Telephone Laboratories, Inc.

CP.* The Cash Value of Information Rate. *J. L. Kelly, Jr.*, Bell Telephone Laboratories, Inc.

9:00 a.m. Problems of Getting Young Engineers from College into Industry

Panel on Electronics: D. I. Cone, Pacific Telephone and Telegraph Company; F. E. Terman, Stanford University; J. M. Cage, Purdue University; and W. R. Hewlett, Hewlett-Packard Company.

Panel on Power: R. O. Broesmer, General Electric Company; J. C. Beckett, Westinghouse Electric Heater Company; W. R. Johnson, Pacific Gas and Electric Company; and M. S. Oldacre, Stanford Research Institute.

2:00 p.m. Opening Ceremony

Address of Welcome. J. S. Moulton, general chairman

2:30 p.m. Annual Meeting

1. Report of the President, M. D. Hooven

2. Report of the Board of Directors, N. S. Hibshman, secretary

3. Report of the Treasurer, W. J. Barrett.

4. Report of the Committee of Tellers on: (a) Votes for nominees for AIEE offices. (b) Proposed Constitutional amendments

5. (a) Introduction of, and presentation of President's badge to M. S. Coover. (b) Response by Mr. Coover

6. Presentation of the Lamme Medal to C. R. Hanna, Westinghouse Electric Corporation

(a) The Establishment of the Medal. J. J. Pilliod, chairman, Lamme Medal Committee. (b) The Career of the Medalist. Dr. J. A. Hutcheson, vice-president, Engineering Research, Westinghouse Electric Corporation. (c) Presentation of the Medal and Certificate by President M. D. Hooven. (d) Response by Mr. Hanna

7. Any other business that may be presented.

8. Address: Dr. A. B. DuMont.

* Conference papers will not be printed by the Institute; they may be available, however, at the meeting at the discretion of the author.

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AIEE Order Department
33 West 39th Street,
New York 18, N. Y.

Tuesday, June 26

9:00 a.m. Section Delegates Conference

9:00 a.m. Transmission and Distribution

CP56-708. Big Bend-Granite Falls 230-Kilovolt Transmission Line. *T. M. Austin*, Bureau of Reclamation

CP56-709. Transmission Planning for Mountain Sheep-Pleasant Valley Project. *W. A. Morgan, G. R. George, R. C. Gust, M. F. Hoick*, The Washington Water Power Company

CP56-710. Economics of Var Supply in a Large Electric Power System. *T. A. Butterworth*, Pacific Gas and Electric Company

56-711. Short-Circuit Tests with Rapid Reclosing on the 220-KV Line Mettlen-Lavorgo. *F. Schurr*, Olten, Switzerland; *P. Baltensperger*, Baden, Switzerland

9:00 a.m. Rotating Machinery—Induction

56-712. The Schrage Motor as a Synchronous Tie Transmitter. *J. P. Landis*, E. I. du Pont de Nemours and Company

CP.* Recent Trends in Pump Motor Design. *W. B. Rice*

CP56-648. Vibratory Systems in Vertical Motor Mountings. *J. M. Shulman*, Westinghouse Electric Corporation

CP56-713. Vibration in Vertical Pumping Systems. *J. H. McKendree, L. A. March*, General Electric Company

9:00 a.m. Magnetic Amplifiers

56-714. Dynamic Behavior of a Three-Phase Magnetic Amplifier. *F. J. Ellert*, General Electric Company

56-715. The Triductor. *P. P. Biringer*, University of Toronto

CP56-716. Characteristic Properties of a Magnetic Frequency Multiplier. *W. Lenhard*, Westinghouse Electric Corporation

CP56-649. A Delta-B Indicator. *H. W. Lord*, General Electric Company

56-717. Superposed Magnetic Fields in Materials and Rectangular Hysteresis Loops. *C. B. Wakeman*, Magnetics, Inc.; *F. J. Beck*, Yale University

9:00 a.m. Instruments and Measurements

CP56-796. New D-C Hysteresigraph. *R. E. Tompkins, J. D. Young*, General Electric Company

CP56-797. An Instrument To Record Voltage Flicker. *V. H. Kraybill*, Commonwealth Edison Company; *H. M. Jensen*, Pennsylvania State University

9:00 a.m. Telegraph Systems

CP56-634. Electrical Teletypewriter Transmitter. *N. N. Biswas*, University of Roorkee, India

56-654. Transmission of Business Machine Data Over Standard Telegraph Channels. *F. B. Bramhall*, Western Union Telegraph Company

CP.* Error Checking with Particular Reference to Telegraph Systems. *R. M. Gryb*, Bell Telephone Laboratories, Inc.

56-655. Control System for Integrated Data Processing. *P. R. Bartorlin*, Western Union Telegraph Company

56-646. Automatic Dispatch System for Half-Duplex Teletypewriter Lines. *J. L. Maxwell, H. E. Farrar*, The Pacific Telephone and Telegraph Company

9:00 a.m. Domestic and Commercial Applications

CP.* The Influence of Practical Considerations on the Use of Electric Heating for Homes. *S. L. Forsyth*, Westinghouse Electric Corporation

CP.* Favorable Economics of Resistance Heating. *J. C. Beckett*, Westinghouse Electric Heater Company

CP56-690. A Study of the Electrical Characteristics of a 20-Suite Electrically Heated Apartment. *J. C. McAdam*, British Columbia Electric Company, Ltd.

CP56-691. The Design and Operation of an Air-to-Air Heat Pump Air Conditioning. *H. E. Burrier*, Southern California Edison Company

CP.* Electric Heating and Heat Pumps. *C. E. Baugh*, Pacific Gas and Electric Company

9:00 a.m. Land Transportation

CP56-762. Rapid Transit Progress in Toronto. *J. G. Inglis*, Toronto Transit Commission

CP.* Rapid Transit Expands in Chicago. *S. D. Forsythe*, Chicago Transit Authority

CP56-763. Adapting a Trolley Coach System to a Changing Traffic Pattern. *S. M. Shockey*, Seattle Transit System

2:00 p.m. Section Delegates Conference

2:00 p.m. Industrial Power Systems

CP56-718. Economics of Distribution Systems. *P. H. Larson*, Holmes and Narver, Inc.

CP56-719. Emergency Electrical Service for Hospitals. *M. L. Buxton*, County of Los Angeles; *P. Belsky*, Westinghouse Electric Corporation

CP56-720. Adequate Capacity in Electrical Services and Distribution Switchgear for the Cannery. *R. S. Wilson*, Processors and Growers Association

CP.* Safety. *E. E. Carleton*, California Division of Industrial Safety

2:00 p.m. Transmission and Distribution

56-721. The Alcunector—An All Weather Connector for Aluminum to Copper Conductors. *E. W. Greenfield, A. H. Salzer*, Kaiser Aluminum and Chemical Corporation

56-722. Emissivity and Its Effect on the Current Carrying Capacity of Stranded Aluminum. *C. S. Taylor, H. E. Hoxie*, Aluminum Company of America

56-723. General Purpose Overhead Distribution Above 5,000 Volts in Urban Areas. *W. R. Bullard*, Ebasco Services, Inc.

CP.* Protection and Application of Series Capacitors Used with Distribution Transformers. *G. G. Auer, L. W. Robbins, N. M. Neagle*, General Electric Company

2:00 p.m. Rotating Machinery

56-635. Experience with High Voltage D-C Insulation Testing of Generator Stator Windings. *E. C. Schurch*, U. S. Bureau of Reclamation

56-724. Analog Computer Representations of Synchronous Generators in Voltage Regulation Studies. *M. Riaz*, Massachusetts Institute of Technology

56-725. The Design of a Very Slow Speed Reluctance Motor for Atomic Reactor Rod Mechanism Drive. *D. A. Gordan*, Westinghouse Electric Corporation

2:00 p.m. Magnetic Amplifiers

56-726. Magnetic Amplifier Control of Switching Transistors. *H. W. Collins*, Westinghouse Electric Corporation

56-727. Magnetic Logic Circuit Control System Design Considerations. *R. J. Van Nice*, Westinghouse Electric Corporation

56-728. Magnetic Pulse Generator Practical Design Limitations. *M. F. Thompson, R. R. Trautwein, E. R. Ingersoll*, North American Aviation, Inc.

CP56-729. The Efficiency of Magnetic Pulse Generators. *B. M. Wolframm*, Magnetic Research Corporation

CP56-730. Instabilities of Push-Pull Magnetic Amplifiers Feeding the Field of an Electrical Machine. *H. F. Storm*, General Electric Company

2:00 p.m. Instruments and Measurements

2:00 p.m. Land Transportation

CP56-764. Developing and Building Rapid Transit Rail Cars. *E. G. Wrausmann*, St. Louis Car Company

CP.* Modern Brakes for Modern Rapid Transit Cars. *C. M. Hinz*, Westinghouse Air Brake Company

CP.* First Year's Operating Experience with New Control Equipment on 100 New York City Subway Cars. *G. W. Weber*, General Electric Company

CP56-765. Recent Developments in Lightweight Rapid Transit Equipment. *H. S. Robinson, J. A. Schoch*, Westinghouse Electric Corporation

2:00 p.m. Computers in Business and Electric Utility Problems

CP.* Some Opportunities for Operations Research in the Electric Power Industry. *W. J. Platt*

CP.* Computers in Business and Industrial Control Problems. *E. M. Grabbe, Harry Larson*

CP56-661. Quasi-Random Access Memory Systems. *G. L. Hollander*, Clevite-Brush Development Company

Wednesday, June 27

9:00 a.m. Power Systems in the Steel Industry

56-637. Electric Power Systems for Steel Plants. *H. N. Cox, L. G. Levy*, General Electric Company

56-731. Centralized Control of Power Systems in the Steel Industry. *W. A. Derr, W. L. Metz*, Westinghouse Electric Corporation

Symposium—The Problem of Fluctuating Loads in the Steel Industry

56-637. Voltage Dips and Flicker. *A. A. Kronsberg* Southern California Edison Company

CP.* Operating Experience with a High-Speed, Turbine Load Regulator. *D. E. Young*, United States Steel Corporation

CP.* The Power-Distribution System of an Integrated Steel Plant. *Donald Stewart, Jr.*, Kaiser Steel Company

9:00 a.m. Communication Switching Systems

56-662. Design Features of Bell System Wire Spring Relays. *H. M. Knapp*, Bell Telephone Laboratories, Inc.

56-650. Manufacture of Wire Spring Relays for Communication Switching Systems. *J. W. Rice*, Western Electric Company, Inc.

56-658. Capability of Sealed Contact Relays. *O. M. Hovgaard*, Bell Telephone Laboratories, Inc.

56-663. The Development of Automatic Manufacturing Facilities for Reed Switches. *J. A. Hosford*, Western Electric Company, Inc.

56-645. Traffic Considerations on Community Dial Offices. *S. J. Lanigan, T. J. McDonough*, Rural Electrification Administration

9:00 a.m. Industrial Power Rectifiers

CP56-664. Resistance Instrument for an Aluminum Reduction Pot Line. *L. H. Wolgast*, Reynolds Metals Company

CP.* Measurements of Arc Drop on Mercury-Arc Rectifiers. *J. E. Hudson*, General Electric Company

CP.* Operating Experiences with the Mechanical Rectifier. *Thomas Controna*, Food Machinery and Chemical Corporation

CP.* A Description of the Electrical Installation of the Anaconda Aluminum Plant at Columbia Falls, Montana. *H. W. Kanzler*, Anaconda Aluminum Company

9:00 a.m. Transmission and Distribution

56-629. Simplified Method for Calculating Intermediate Faults on Mutually Coupled Transmission Lines. *M. J. Lantz*, Bonneville Power Administration

56-627. Electrical Resistance to the Earth of a Live Tree. *F. M. Defandorf*, National Bureau of Standards

56-732. Reduced Insulation in Power Systems at the Higher Voltages—The Problems It Presents. *P. L. Ballaschi*, Portland, Ore.

56-733. A New Approach to the Calculation of the Lightning Performance of Transmission Lines. *C. F. Wagner*, Westinghouse Electric Corporation

9:00 a.m. Transformers

56-734. A Study of the Co-Ordination of Modern Arresters and Transformer Insulation. *E. J. Adolphson, F. J. Vogel*, Allis-Chalmers Manufacturing Company

56-735. Switching Surge and Long Duration Voltage Tests on Transformer Insulation. *W. C. Farneth, F. J. Vogel*, Allis-Chalmers Manufacturing Company

56-628. Minimum Cost Loading of Transformers. *A. Klopfenstein*, Southern California Edison Company

CP56-736. Reduction of Audible Sound of Transformers by the Suspension Method of Installation. *C. P. Xenis*, Consolidated Edison Company of New York, Inc.

CP.* Low-Remanence Aluminum Iron. *D. Pavlovic, K. Foster*, Westinghouse Electric Corporation

9:00 a.m. Magnetic Amplifiers

CP.* Teaching Magnetic Amplifier Circuits. *H. C. Bourne*, University of California

56-626. Alternating Current Control of the Half-Wave Bridge Magnetic Amplifier. *T. Bratoiu*, General Motors Corporation; *N. L. Schmitz*, University of Wisconsin

CP56-737. A Stable Low-Level Magnetic Amplifier. *R. Cockrell*, Boeing Airplane Company

CP.* Fast Response Low-Level Magnetic Amplifiers. *A. Hoffman*, Convair

56-738. Inverse Time Underfrequency Relay. *R. G. Hoft*, General Electric Company

9:00 a.m. Management

CP.* Organizing To Build the Commonwealth Edison Nuclear Power Plant. *J. E. Maider*, Commonwealth Edison Company

CP.* Management Development in the Communications Field. *Glen Ireland*, Pacific Telephone and Telegraph Company

CP.* How an Engineering Education Fits an Individual for a Management Position. *G. C. S. Benson* Claremont Men's College

9:00 a.m. Wire Communication Systems

CP56-799. Single Sideband Subscriber Carrier. *W. E. Noller*, Lynch Carrier Systems, Inc.

CP56-798. Application of Single Sideband Subscriber Carrier to Rural Telephone Lines. *G. L. Curtis*, Lynch Carrier Systems, Inc.

CP56-800. FM Subscriber Carrier. *Elvin Kravis*, Panhandle Electrical Construction Company

CP.* P1 Carrier System. *R. C. Boyd*, Bell Telephone Laboratories, Inc.

2:00 p.m. Substations

CP.* Development of Automatic Dry Chemical Fire Protection Systems for Large Outdoor Transformers. *E. F. Weaver*, Pennsylvania Power and Light Company

CP56-739. Insulator Washing in Substations. *R. S. Melville*, Southern California Edison Company

TWO LARGE POWER transformers being made ready for tests at the Westinghouse plant at Sunnyvale, Calif. The big 3-phase transformers are rated at 10,000 kva each and step down the transmission line voltage from 69,000 to 12,470 volts.

A SIGHTSEEING boat trip to the Pacific Gas and Electric Company's Steam-Electric Plant at Pittsburg, Calif., will be one of the highlights of the Summer Meeting.

CP56-740. Cleaning Insulators in Energized Substations. *C. L. Collins, J. H. Rutter*, Department of Water and Power, Los Angeles, Calif.

56-636. New Lightning Arrester Standard. *H. R. Armstrong*, Detroit Edison Company; *F. M. Defandorf*, National Bureau of Standards; *A. M. Opsahl*, Westinghouse Electric Corporation

CP56-741. The Application of Lightning Arresters on a Large Power System. *H. R. Armstrong*, Detroit Edison Company

2:00 p.m. Communication Switching Systems

56-631. Recent Developments in Four-Wire Switching of Long-Distance Telephone Circuits. *Imre Molnar*, Automatic Electric Company

56-665. The Full Stature of the Crossbar Tandem Switching System. *John Mezzar*, Bell Telephone Laboratories, Inc.

56-668. Electronics in Telephone Switching Systems. *A. E. Joel*, Bell Telephone Laboratories, Inc.

CP56-666. A Magnetic Drum Storage System Considered for Use as a Common Sender in Nationwide Dialing. *H. F. May*, Bell Telephone Laboratories, Inc.

56-667. Recent New Features for the Number 5 Crossbar Switching System. *J. W. Dehn, R. E. Hersey*, Bell Telephone Laboratories, Inc. Re-presented for discussion.

2:00 p.m. Transformers

56-742. Determination of Impulse Stresses Within Transformer Windings by Computers. *J. H. McWhirter, C. D. Fahrnkopf, J. H. Shuls*, Westinghouse Electric Corporation

56-743. Effect of Impulse Testing on Transformer Iron Loss. *J. H. McWhirter, T. R. Specht, W. D. Albright*, Westinghouse Electric Corporation

56-744. Ultrasonic Detection and Location of Electrical Discharges in Insulating Structures. *J. G. Anderson*, General Electric Company

56-745. Evaluation of Dielectric Strength Gauges for Transformer Oil. *K. H. Weber, R. B. Kaufman*, General Electric Company

CP56-746. Use of Aluminum Strip Conductor in Dry Type Transformers. *J. C. Meakins, T. E. Lewis, J. Staley*, Reynolds Metals Company

2:00 p.m. Magnetic Amplifiers

56-747. The Series Magnetic Amplifier, Part I—The Four Modes of Operation. *R. C. Barker*, Yale University

CP56-748. The Series Magnetic Amplifier, Part II—The Mechanisms of Gain and Time Constant. *R. C. Barker*, Yale University

56-749. Diode Shunting in Magnetic Amplifiers. *J. L. Louvaas, J. E. Dolan*, Bendix Aviation Corporation

CP.* A Silicon Diode Reference Unit. *W. H. Woodworth*, Michelson Laboratories

56-750. The Simple Reactor Circuit; Its Operation and Mode Transition. *J. F. Ringelman, A. L. Fenaroli*, Westinghouse Electric Corporation

CP.* Evaluation of Materials for Reducing Vibration Effects on Toroidal Cores. *W. F. Horton*, Lear, Inc.

2:00 p.m. Television and Aural Broadcasting Systems

CP.* Recent Developments in High Fidelity Amplifiers and Other Equipment. *F. H. McIntosh*, Frank H. McIntosh Consulting Radio Engineers

CP.* Remote Control of Directional and High Power Standard Broadcast Stations. *A. P. Walker*, Association of Radio and TV Broadcasters

CP.* The Impact of Recent Research on Television and Aural Broadcasting Systems. *G. H. Brown, C. N. Hoyler*, Radio Corporation of America Laboratories (Demonstration)

2:00 p.m. Ethics in Engineering Practice

CP.* The Consulting Engineer's Viewpoint. *H. J. Brunnier*, consulting engineer

CP.* Professional Ethics and the Government Engineer. *E. C. Starr*, Oregon State College

CP.* Ethics for Organizations. *C. A. Powel*, past president, San Mateo, Calif.

2:00 p.m. Safety

CP.* Field Treatment of Electric Shock Cases. *W. B. Kouwenhoven*, The Johns Hopkins University

CP56-761. Emergency Lighting for Fire Safety. *R. S. Moulton*, National Fire Protection Association

CP56-669. Testing for Safety—Safely. *J. A. MacNabb*, Underwriters' Laboratories

2:00 p.m. Analogue-Digital Converters and Combined Computation

CP.* Addaverters I—Specifications for Analog-Digital Analog Converting Equipment for Simulation Use. *R. M. Lager*, Convair

CP.* Logical and Functional Organization of the AD-DA Verter System. *B. M. Gordon*, EPSCO, Inc.

CP.* Design and Construction of AD-DA Verter System. *Eli Anfanger*, EPSCO, Inc.

CP.* Addaverters IV—Combined Analog-Digital Computer Operation. *J. L. Greenstein*, Convair

Thursday, June 28

9:00 a.m. Mining and Metal Industry

CP.* This Is Automation. *A. C. Parsons*, General Electric Company (movie)

CP56-675. Automatic Control Systems in Steel Processes. *W. K. Scott*, United States Steel Corporation

CP.* Computer Applications in the Metal Working Industries. *L. F. Stringer*, Westinghouse Electric Corporation

CP.* Automatic Control for Continuous Processing Lines. *F. L. Reed*, Westinghouse Electric Corporation

9:00 a.m. System Engineering

CP56-642. The Connecticut Capacity Co-ordinating Plan. *E. C. Brown*, The Hartford Electric Light Company; *C. T. Hughes*, Connecticut Light and Power Company; *R. G. Warner*, United Illuminating Company

CP56-670. Summary of Some Aspects of Tie Line Bias Control on Interconnected Power Systems. *Nathan Cohn*, Leeds and Northrup Company

CP.* Automatic Operation of Interconnected Areas. *A. F. Glimn, L. K. Kirchmayer, H. H. Chamberlain*, General Electric Company

CP56-671. Penalty Factors from Power System Equations. *P. G. Lubitich*, Los Angeles Department of Water and Power

56-672. Some General Theorems on Power Flow in Linear Networks. *J. F. Calvert, T. W. Sze*, University of Pittsburgh. Re-presented for discussion

9:00 a.m. Switchgear

56-751. Mechanical Features of New Frame Mounted Outdoor Oil Circuit Breakers. *E. R. Perry, J. F. Claflin, W. L. Vance*, Allis-Chalmers Manufacturing Company

56-752. The Development and Testing of a 300-Kv Air-Blast Circuit-Breaker for Severe Duties. *J. Christie, D. F. Amer, A. F. B. Young*, A. Reyrolle and Company, Ltd.

CP56-701. A New Universal Mechanically Trip-Free, Four Bar Linkage Mechanism for Intermediate Voltage Power Circuit Breakers. *H. L. Post*, Allis-Chalmers Manufacturing Company

CP56-753. Gas Blast Switch—Tests on 230-Kv System. *P. E. Richardson*, U. S. Bureau of Reclamation; *Aron Foti*, I-T-E Circuit Breaker Company

9:00 a.m. Carrier Current

56-651. Application of Transistors in Power Line Carrier Relaying. *W. C. Frazier*, The Potomac Edison Company; *E. E. Scheuman*, Westinghouse Electric Corporation

56-630. A Microwave Communication System for the Southern Colorado Power Company. *G. D. Perry, Jr.*, Southern Colorado Power Company; *E. Langone*, General Electric Company

CP56-754. Frequency Shift Microwave Channelizing Equipment for Line Protective Relaying. *M. E. Strong, W. R. Robinson*, Westinghouse Electric Corporation

9:00 a.m. Television and Aural Broadcasting Systems

CP.* Television Networks for the San Francisco Convention. *E. D. Barcus, A. E. MacMahon*, Pacific Telephone and Telegraph Company

CP.* Color Kinescope Recording on Embossed Film. *C. H. Evans, R. B. Smith*, Eastman Kodak Company

56-673. A Video Visual Measuring Set with Sync Pulses. *P. T. Sproul*, Bell Telephone Laboratories, Inc

CP.* VHF Propagation Over Rough Terrain. *A. G. Sparling*, Stations KHQ AM and TV

9:00 a.m. Chemical Industry

CP56-674. Electrical System for a Nuclear Reactor. *E. P. Peabody, D. S. Brereton*, General Electric Company

CP.* Cathodic Protection for Steel Retention Tanks Containing Reactor Coolant Water. *C. S. Buchalt*, General Electric Company

CP.* Minimizing the Fifth and Seventh Harmonics from A-C Distribution System. *W. R. Kiltz*, The Dow Chemical Company

CP56-480. Expansion of Electrical Facilities in Chemical Plants Utilizing Existing Switchgear. *H. N. Hickok*, General Electric Company

9:00 a.m. Electronic Circuitry

56-756. Magnetic Regulation Transistor Power Supply. *L. F. Lyons*, Bendix Aviation Corporation

CP56-757. Keyed, Phase-Sensitive Demodulators. *Robert B. Mark, P. R. Johannessen, W. X. Johnson*, Massachusetts Institute of Technology

56-758. Application of Junction Transistors to Carrier Frequency Computing Amplifiers. *W. A. Curtin*, Radio Corporation of America

56-759. Synchronization Accuracy Obtainable with Multiplier Phototubes. *L. Lavi*, Fairchild Controls Corporation

CP56-760. A Comprehensive Timing System for Field Testing. *C. K. Reynsford*, Vitro Laboratories

9:00 a.m. Industrial Power Systems

56-625. Distributing Large Single-Phase Loads in Limited Capacity Three-Phase Power Systems. *G. F. Arroyas*, University of California; *K. G. Lakey*, U. S. Navy

CP.* Petroleum Refinery Electrical Power Systems. *G. R. Dunbar*, Westinghouse Electric Corporation

CP56-767. A Transient Stability and Voltage Study for a Modern Oil Refinery Distribution System. *C. W. Boier*, C. F. Braun and Company; *S. R. Durand, D. Dalasta*, Allis-Chalmers Manufacturing Company

2:00 p.m. Mining and Metal Industry

56-639. Transient Characteristics of D-C Metal Rolling Motors and Generators. *E. P. Smith*, General Electric Company

56-638. Analysis of Tandem Cold Reduction Mill with Automatic Gauge Control. *R. A. Phillips*, General Electric Company

56-656. Incremental Control Equations for Tandem Rolling Mills. *J. H. Courvoular, J. M. Ham*, University of Toronto

CP.* Modern Computer Analysis for the Design of Steel Mill Control Systems. *J. E. Reider, P. Spergel*, Industrial Nucleonics Corporation

2:00 p.m. Power Generation

56-768. Development of the Electrical Aspects in Outdoor Steam-Electric Operating Stations on the Pacific Gas and Electric Company System. *Einar Nilson*, Pacific Gas and Electric Company

56-769. Outdoor versus Indoor Steam-Electric Stations in the Houston Area. *L. K. Del'Homme*, Houston Lighting and Power Company

CP56-660. Salient Electrical Features of Muskingum River Plant. *V. P. Rader, C. P. Zimmerman*, American Gas and Electric Service Corporation

CP56-770. Design Changes for Unit 3, Meramec Plant. *R. W. Gaskins*, Union Electric Company of Missouri

CP56-771. Refinements in Design of Steam-Electric Generating Stations. *J. L. Cohen*, Southern California Edison Company

2:00 p.m. System Engineering and Computers

56-676. Transient Stability Angular Increment Computer. *H. Wood*, Southern California Edison Company

56-677. Digital Computer Solution To Determine Economical Use of Hydro Storage. *D. L. Johnson*, University of Washington

56-678. Exact Economic Dispatch Digital Computer Solution. *R. B. Shipley, Martin Hochdorf*, Tennessee Valley Authority

56-679. The Use of Computing Machines in the Statistical Evaluation of Electric Components. *W. E. Andrus, Jr.*, International Business Machines Corporation

56-680. Analysis of a Sampled Data Servomechanism Performed on the IBM 650 Magnetic Drum Data Processing Machine. *B. M. Tostanoski*, International Business Machines Corporation

2:00 p.m. Switchgear

56-772. Current Limiting Fuses—Their Characteristics and Applications. *P. C. Jacobs*, The Chase-Shawmut Company

CP56-773. Co-ordination of Current Limiting Fuses and Low Voltage Air Circuit Breakers. *M. S. Carlson, W. H. Edmunds*, I-T-E Circuit Breaker Company

CP56-774. A New High Interrupting Capacity Low Voltage Circuit Breaker. *W. H. Edmunds*, I-T-E Circuit Breaker Company

56-775. Testing Large Air Circuit Breaker Trip Devices. *C. H. Titus, L. H. Sparow*, General Electric Company. Re-presented for discussion

2:00 p.m. Basic Sciences

56-681. Dynamax, A New Crystal and Domain Oriented Magnetic Core Material. *G. H. Howe*, General Electric Company

56-682. Investigations Concerning Polarization in Barium Titanate Ceramics. *G. W. Marks, L. A. Mouson*, USN Electronics Lab. *D. L. Waidelich*, University of Missouri

CP.* High-Permeability Aluminum-Iron. *D. Pavlovic, K. Foster*, Westinghouse Electric Corporation

56-787. The Analytical Design and Evaluation of Electromagnets. *M. J. Kelly, J. E. Wallace*, International Business Machines Corporation

56-684. Graphical Determination of the Fourier Series Coefficients. *W. H. Middendorf*, University of Cincinnati

2:00 p.m. Television and Aural Broadcasting Systems

CP.* Projection Display for Color Television Receivers. *D. E. Foster*, Hazeltine Research Corporation of California

CP.* Adaptation of the CHROMATRON Tube for Military Applications. *D. R. Cone*, Chromatic TV Laboratories, Inc.

CP56-688. New Sloan Scan TV System for Closed Circuit Applications. *G. H. Fathauer, R. H. Smith, Jr.*, Thompson Products, Inc.

2:00 p.m. Chemical Industry

CP.* The Germanium Rectifier Is Growing Up. *R. M. Crenshaw*, General Electric Company

CP56-689. Electric Cable Insulation in Chemical Plants. *J. E. Parker*, Carbide and Carbon Chemicals Company

CP56-491. High Voltage D-C Testing of Cables and Cable Fault Locations. *B. J. Nankervis*, The Dow Chemical Company

CP56-470. Corona in Metal-Clad Switchgear. *H. O. Borque*, Ethyl Corporation

2:00 p.m. Radio Communication Systems

CP.* Emergency Use of Microwave Radio in Northern California. *M. W. Walther, C. S. Watkins*, Pacific Telephone and Telegraph Company

56-692. Impedance of Thin Wire Loop Antenna. *J. E. Storer*, Harvard University

CP.* Tacan. *H. Buisgnies*, Federal Telecommunications Laboratories

Friday, June 29

9:00 a.m. Power Generation and System Engineering

CP56-635. Probability Calculations for System Generation Reserves. *Carl Kist, G. J. Thomas*, Department of Water and Power, Los Angeles, Calif.

56-643. Accuracy Considerations in Economic Dispatching of Power Systems—Part I. *A. F. Glimn, L. K. Kirchmayer*, General Electric Company; *V. R. Peterson, G. W. Stagg*, American Gas and Electric Service Corporation

56-641. A New Automatic Dispatching System for Electric Power Systems. *K. N. Burnett, D. W. Halfhill, B. R. Shepard*, General Electric Company

56-776. Eastlake Reappraised. *C. F. Paulus*, Cleveland Electric Illuminating Company

9:00 a.m. Insulated Conductors

56-702. An All-Purpose Directional Impulse Method of Cable Fault Locating and Identification. *E. K. Anderson, Jr.*, Consolidated Edison Company of New York, Inc.

56-703. High Temperature Power Cable with Silicone Insulation. *C. T. Hatcher*, Consolidated Edison Company of New York, Inc.; *A. R. Lee*, General Electric Company

CP56-704. Analysis of Conductor Economics. *R. C. Blankenburg*, Southern California Edison Company

CP.* Jointing Aluminum Sheathed Power Cable. *E. J. Merrell, R. A. Rustbach*, Phelps Dodge Copper Products Corporation

CP56-705. Aluminum Sheathed Cable with Welded Splice Sleeves. *G. T. Nicholson, G. P. Adams*, Niagara Mohawk Power Corporation

9:00 a.m. Computing Devices and Applications

56-693. Some Engineering Aspects of the Machine Translation of Language. *R. E. Wall, Jr.*, University of Washington

CP56-694. Zero Signal Reliability in Magnetic Shift Registers. *O. J. Van Sant*, U. S. Naval Ordnance Laboratories

56-695. Magnetic Data Recording Theory; Head Design. *A. S. Hoagland*, University of California

56-696. Optimum Linear-Segment Function Generation. *Howard Homer*, Electronic Associates

9:00 a.m. Basic Sciences—Semiconductors

CP.* Physics of Semiconductors. *C. Kittel*, University of California

CP.* Transistor Physics. *W. Shockley*, Shockley Semiconductor Laboratories

CP.* Junction Transistors. *L. Valdez*, Shockley Semiconductor Laboratories

CP.* Application of "3-5" Compounds to Devices. *H. W. Henkels*, Westinghouse Electric Corporation

9:00 a.m. Feedback Control Systems

56-777. An Experimental Treatment of Nonlinear Servomechanisms. *R. S. Neiswander*, Aerojet-General Corporation

56-778. A Time Dependent Nonlinear Compensating Network. *J. C. Clegg*, University of Utah

56-779. A Step-by-Step Method for Transient Analysis of Feedback Systems with One Nonlinear Element. *T. M. Stout*, Ramo-Wooldridge Corporation

56-640. A General Technique for Approximating Transient Response from Frequency Response Asymptotes. *G. A. Biernson*, Massachusetts Institute of Technology

9:00 a.m. Wire Communication Systems

56-780. Where We Are and Where We Are Going in Telephone Transmission. *H. R. Huntley*, American Telephone and Telegraph Company

56-781. Transmission Rating of Telephone Sets. *K. S. Johnson, J. B. Epps, Jr.*, Rural Electrification Administration

CP56-782. Pacific Coast Tool Transmission Network. *W. L. Carter, R. L. Messner*, Pacific Telephone and Telegraph Company

56-783. Telephone Carrier Frequency Networks. *G. D. Wallenstein*, Lenkurt Electric Company

56-784. Influence of Noise on Telephone Signaling Circuit Performance. *L. A. Weber*, Bell Telephone Laboratories, Inc.

9:00 a.m. Nucleonics

CP.* Progress in the Development and Design of the Dresden Nuclear Power Plant. *J. R. Walcott*, General Electric Company

CP.* Control and Instrumentation of the Dresden Nuclear Power Plant. *E. P. Peabody*, General Electric Company

CP.* Description of the Pressurizer Water Reactor (PWR) Power Plant at Shippingport, Pennsylvania. (a) **Nuclear Power Generation,** *J. W. Simpson*, Westinghouse Electric Corporation, *M. Shaw.* (b) **Turbine Generator Plant.** *R. B. Donworth, W. J. Lyman*, Duquesne Light Company. (c) **Core Design.** *I. H. Mandil, N. J. Palladino*

CP.* Sodium Graphite Reactor. *Chauncey Starr*, North American Aviation

CP.* A Developmental Fast Neutron Breeder Reactor. *A. Amorosi, A. P. Donnell, H. A. Wagner*, APDA

2:00 p.m. Power Generation

CP56-785. Hydroelectric Development on the North Fork of the Kings River. *W. R. Johnson, D. P. Dinapoli, J. B. Cooke*, Pacific Gas and Electric Company

56-786. Electrical Features of the Sir Adam Beck-Niagara Generating Station #2, The Hydro Electric Power Commission of Ontario. *W. E. Taylor*, Hydro-Electric Power Commission of Ontario

DR. HANS MOTZ of Stanford University's Microwave Laboratory, which will be visited during the Meeting, adjusts the echelette spectrometer, a key part of the millimeter wave generator he invented.

Courtesy Stanford University

CP.* Single-Line Diagrams—Hydro Stations of Aluminum Company of Canada, Ltd. *J. T. Madill, W. O. Cadrington*, Aluminum Company of Canada, Ltd.

CP.* Round-Table Discussion—Cloud Seeding. *C. P. Smith*

2:00 p.m. The Place of Analogue Versus Digital Computers in the Solution of Engineering Problems

CP56-687. Analog Versus Digital Techniques for Engineering Design Problems. *D. B. Brown*, Westinghouse Electric Corporation

56-697. Numerical Integration of Differential Equations on the 704 EDPM. *H. H. Anderson, J. R. Johnson*, International Business Machines, Inc.

CP.* Factors Favoring an Analog Computer. *R. Favreau*

CP.* Some Relationships Between Analog and Digital Computers. *R. Hamming*

CP.* Panel discussion.

2:00 p.m. Basic Sciences and Solid-State Devices

CP56-788. Two Simple Solid-State Analog Dividers. *E. A. Sack*, Pittsburgh, Pa.

CP56-789. Discontinuous Transition Time Between Stable States in Ferroresonant Circuits. *Sheldon Plotkin*, University of California

56-686. Subharmonic Response of the Ferroresonant Circuit. *Egon Brenner*, The City College of New York

56-685. Computation of the Impedances of Nonuniform Lines by a Direct Method. *L. A. Pipes*, University of California

CP56-683. Series Circuit Incorporating a Nonlinear Reactor. *R. P. Evans*, North American Aviation, Inc.

2:00 p.m. Feedback Control Systems

56-644. Discrete Compensation of Sampled-Data and Continuous Control Systems. *E. I. Jury, W. Schroeder*, University of California

56-790. Hidden Oscillations in Sampled-Data Control Systems. *E. I. Jury*, University of California

56-791. Feedback Techniques Applied to the Single Phase Transformer. *E. Mishkin*, Polytechnic Institute of Brooklyn

56-792. Envelope Transfer Function Analysis in A-C Servosystems. *Marvin Panzer*, Polytechnic Institute of Brooklyn

CP56-793. Theory of A-C Servomechanisms. *C. W. Hewlett, Jr.*, General Electric Company

2:00 p.m. Radio Communication Systems

56-659. Microwave Facilities with Built-In Reliability. *R. G. Kuck*, The Pacific Telephone and Telegraph Company

56-698. Automatic Protection Switching for TD-2 Radio System. *G. H. Kiemm*, Bell Telephone Laboratories, Inc.

56-699. Microwave for Telephone Companies. *W. C. Fisher*, Lenkurt Electric Company, Inc.

56-700. Southwest Oregon Radio System for Bonneville Power Administration. *D. J. Marihart*, Bonneville Power Administration; *D. L. Wylie*, Chicago, Milwaukee, St. Paul and Pacific Railroad Company

2:00 p.m. Nucleonics

CP.* General Purpose Electronic Areas for Nuclear Research. *A. J. Stepenka*

CP.* The Problems of Making Major Repairs to Production Reactors. *E. E. Weyrtis, W. J. Downs*, General Electric Company

CP.* The Westinghouse Testing Reactor. *A. R. Jones*, Westinghouse Electric Corporation

CP.* The Belgian Thermal Reactor. *R. L. Witzke, G. Tavernier*, Westinghouse Electric Corporation

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(*Continued from page 557*)

average of last three scores should also be registered with the Committee. Any golfers desiring noncompetitive golf on days other than June 26 should consult the Committee at the Sports Desk.

Salmon Derby. Salmon fishing is generally excellent outside the Golden Gate during June, and whether you are an Izaak Walton or a rank neophyte, you will never be sorry you decided to take part in this AIEE Salmon Derby. Preparation is absolute minimum as all that is needed is to bring some warm loafing garb; everything else is provided, even the license if necessary. Of course, if you have some pet fishing gear you want to use, bring it along.

The cabin power boats, accommodating 6 to 10 persons each, are clean and comfortable. Boat skippers are very helpful and will be glad to give full instructions to the lesser experienced on how to fish. Fishing tackle and bait, as well as a box lunch, will be furnished each person.

A bus will leave from the Palace, St. Francis, or Fairmont hotels about 5:30 a.m., June 27, for the short trip across the Golden Gate Bridge to Sausalito, from where the "AIEE Fishing Fleet" will leave about 6:30 a.m. for the salmon fishing grounds. The trip out under the impressive Golden Gate Bridge, with beautiful views of San Francisco in the background, will be long remembered.

The fleet will return to Sausalito about 2:30 p.m., each boat loaded to the gunnels (we hope) with salmon, and some could be 50 pounders. Facilities will be available for packing your catch for shipment home or maybe you will want to mount the "big one" for your den. You should be back in San Francisco by 3:30 or 4:00 p.m. at the latest.

In addition to impromptu "pots," you will compete for special Derby prizes which will be awarded during the luncheon on Thursday.

Plan now for this big AIEE Salmon Derby. Form your own party if you wish and ask the Committee to assign you your own boat. The Committee will do everything possible to group boat companions as desired. Check in promptly with the Sports Committee on arrival, but also it would be most helpful to the Committee if you would send in as soon as possible your advance registration card and indicate on it your intention to participate in the big Salmon Derby. Tickets, all inclusive, $15.

General Information

General information may be obtained at the registration desk. A table for mail and memoranda will be maintained and there will be a bulletin board for posting notices and messages. Information on inspection trips and entertainment features will also be displayed.

Late June weather in San Francisco will probably be pleasantly cool. Fall-type clothing is recommended.

Hotel Reservations

Rooms have been set aside for members and their guests at these hotels: Fairmont (headquarters hotel), $10.50–19; Mark Hopkins, $10–20; Huntington, $8–15; Chancellor, $5.75–8.75; Plaza, $9–15; Hillcrest, $4–5.50; Alexander Hamilton (twin beds only), $10–12; Canterbury, $8–10; Cartwright, $7–8; and Cecil, $5–8.50. Rooms will be available in nine other hotels at prices of $6–10. Write for reservations to AIEE Hotels Committee, Box 4588, San Francisco 1, Calif. Be sure to make use of the hotel reservation sheet included with the mailed announcement concerning the

Summer and Pacific General Meeting. All reservations will be handled on a first-come first-served basis.

Some motels are available in San Francisco. A list of these and rates may be obtained by writing to: E. A. Nickelsen, California Pacific Utilities Company, 405 Montgomery Street, San Francisco 4, Calif.

IEE-AIEE Take Action To Waive Member Entrance Fees

BY SIMILAR ACTION of the governing bodies of the two national organizations, Corporate Members of the Institution of Electrical Engineers of Great Britain (IEE) and the AIEE will, under certain conditions, be admitted to the other society without the payment of entrance fees.

Corporate Members and Graduates of IEE who have taken up permanent residence in the United States may, if application is made within 12 months of taking up such residence, be admitted to membership in AIEE, without the payment of entrance fees. Those already resident here are extended the same privilege, provided application is made before June 1, 1957. The same arrangement has been made by the IEE for members of AIEE resident in Great Britain.

The Bylaws of the AIEE, amended by the Board of Directors at its Meeting of April 3, 1956, now read as follows on the subject:

"A member of the Institution of Electrical Engineers (Great Britain), who is a Corporate Member or a Graduate in good standing, may apply for admission to an equivalent grade of membership in the American Institute of Electrical Engineers; and without paying the required entrance fees, provided the applicant has taken up permanent residence in the U.S.A., and makes application within twelve months following the established date of his permanent residence, or, if already a resident there, within twelve months of the appearance of this notice."

In the March 1956 issue of the *Journal* of the IEE, the corresponding action taken by that body is reported. It states that:

"The following are the conditions under which the entrance fee will be waived:

'On election to the Institution, if the applicant is a Fellow, Member or Associate Member of the American Institute of Electrical Engineers in good standing, permanently resident in Great Britain, including Northern Ireland, the Isle of Man and the Channel Islands, and makes application within twelve months of his taking up residence in Great Britain or, if already resident there, within twelve months of the appearance of this notice'."

South West District Meeting Establishes Record Attendance

AN OUTSTANDING MEETING of the South West District was held in Dallas, Tex., April 2–4, 1956, establishing an all-time attendance record of 1,230 for district meetings. The previous record of 900 was set by a Great Lakes Regional Meeting in Chicago, Ill., November 28–30, 1927. The success of the meeting may be attributed to a well-arranged program built around the theme, "Electricity in Aircraft," combined with an exhibit of the latest airborne electrical apparatus, components, and support items. Eight technical sessions on aircraft were held together with a number of sessions in the light and power field, several industrial sessions, and a management panel. The Student Branch Conference and prize paper competition, a General Session, two luncheon meetings, inspection trips, a dinner-dance, and special entertainment arrangements for the ladies rounded out the program.

Luncheon Meeting

An important address setting off the meeting theme, "Research and Development Efforts in the U. S. Air Force," was given by William Weitzen, Deputy Assistant Secretary, U. S. Air Force Research and Development Operations. The speaker outlined necessary long-range planning, as well as the factors and regulations for which industry should design, such as speeds that approach Mach 2.0 at higher altitudes, in the light of the present engineering manpower and scientific personnel shortage. Full text of the address appears in this issue of *Electrical Engineering*, page 522. Past-President E. B. Robertson presided, and introduced L. E. Cooke, president Dallas Electric Club, who introduced the speaker. Mr. Weitzen received the Air Force Civilian Meritorious Award in 1954.

General Session

Feature of the General Session, which carried out the theme of the meeting, "Electricity in Aircraft," was an address by C. J. McCarthy, chairman of the board, Chance Vought Aircraft Inc., and president of the Institute of Aeronautical Sciences. Beginning with the early accomplishments of the Wright Brothers, Mr. McCarthy explained how modern fighter planes had become complex pieces of equipment. He stated that within the Dallas area there were four airplane companies employing 750 electrical engineers. He predicted that the present trend toward increased use of electricity with new automatic stabilizer and servo systems would continue. The rapid rise and air speed would require vastly improved component designs. As systems must be serviced by unskilled people, it will be essential to make the systems simpler and free from faulty components. In conclusion, he stressed that industry must continue to maintain the air superiority of the United States by increasing intensity of research and development.

Vice-President S. M. Sharp presided. After the Invocation service by Dr. Herbert Howard, the speaker was introduced by G. L. MacGregor, president, Texas Utilities Company.

Luncheon in Honor of Board of Directors

On this auspicious occasion, President M. D. Hooven addressed the meeting on "AIEE and Its Future." He outlined the organization of the 50 technical committees and 250 subcommittees in 6 broad divisions using the Committee on Air Transportation as a typical example. He also referred to the work of the general committees, the Sections, and the Student Branches, as well as the complex interrelationships with other organizations. The full text of the address was published in *Electrical Engineering*, May 1956, pages 405–7. Director P. G. Wallace presided and introduced the speaker.

Courtesy T. W. Collins

IN CONVERSATION at the South West District Meeting (*left to right*), William Weitzen, Deputy Assistant Secretary, U. S. Air Force; Director P. G. Wallace; M. S. Coover, AIEE president-elect; and E. B. Robertson, AIEE past-president.

Courtesy T. W. Collins

THE MANAGEMENT PANEL at the South West District Meeting (*left to right*) W. N. Estel, director of personnel; A. C. Polk, vice-president and general manager; and J. G. Staudt, executive vice-president, all of Dowell Inc; R. D. Ledbetter, who presided; W. W. Lynch, moderator and president of Texas Power and Light Company; and H. H. Race, consultant manager, Development Education, General Electric Company.

Student Branch Conference

The District 7 Student Branch Conference was held during the meeting with the Joint Student Branch at Southern Methodist University (SMU) acting as host. Students presented 17 papers from as many different schools, in three sessions. H. C. Baker, outgoing chairman, SMU Joint Student Branch, presided at the first session. Allan Meinstein present chairman, presided at the second, and D. C. Donohoe, secretary, presided at the third session. Some of the many excellent presentations were accompanied by demonstrations. After a close contest, the judges announced the winner to be W. F. Osborn of Texas A and M College, for his paper "A Compact Operational Amplifier Designed for Use in a Table Model Computer." The award is even more significant because Mr. Osborn was a veteran who built the operational amplifier economically, with his own money. The following papers received honorable mention: "The Displacement Log—A New Exploratory Tool for the Oil Industry," H. C. Baker, SMU; and "An Automatic Shutter for Ballistic Cameras," T. W. H. Caffey, New Mexico College of A and M Arts.

On Tuesday morning, a breakfast meeting for the counsellors of District 7 was held in the Adolphus Hotel. There was also a breakfast meeting for Student Branch chairmen. In the afternoon, an informal tea-dance took place in the Umphrey Lee Student Center on the SMU campus.

Aircraft Technical Sessions

Eight aircraft technical sessions were held, including one evening session when 35 papers sponsored by the Air Transportation Committee were presented. Subject matter, covering the whole field of aircraft electrical design and applications problems, included generators, their parallel operation; definitions for voltage modulation characteristics in 380 to 480 cps systems; reactive load division; and selective protection, as well as frequency modulation and load division instability in parallel alternator 400 cycle systems. In electronics, the subjects discussed were transistor circuits and transistor applications, design of integrated electronics systems, power supplies, cold cathode triodes and timing circuits, and application of wired television to augment and extend human vision. In another session, electronic equipment environmental design was considered relative to vibration and shock, control in high performance aircraft, and an effective method of forced air cooling. Other sessions presented papers about storage batteries and ground power supply, its precise control; and design and development of a new silicon rectifier d-c power supply; feedback control and reliability; testing for specification compliance; production testing of a-c power systems after installation; and analyzing missile electrical system reliability.

Power Sessions

At 7 power sessions 20 papers were presented. A session on communications supervisory control was of considerable interest to power people. Subjects included were power generation in which the large electrical manufacturers presented papers on nuclear power, recent advances in turbine and generator design, and trend and development in large turbine-generators. In a session on power transmission, lighting protection of H-frame transmission lines using one expulsion protected tube per structure was presented. A unique design for 230-kv wood pole construction, and the calculations of mutual sequence impedances of parallel transmission lines were also outlined. In distribution, two sessions dealt with splicing and terminating power cables, capacitor switching, load characteristics and their effects on distribution system design, connector performance, and fuse protection of high voltage transformers. In a session on distribution and substations, a panel of experts from several power and light companies and electrical manufacturers presented their viewpoints and discussed items to be taken into consideration in the use of distribution lightning arresters. In a session on switchgear, the use and tests of a new vacuum switch for power systems for the switching of capacitor banks and the interruption of charging currents was described. The design of new braidless side-break switches was also detailed. Papers in the session on communications and supervisory control which were of interest to power people, treated a portable VHF radio system for emergency communications, the need to simplify utility radio communications, and the method utilized to remote control unattended pump stations of the Great Lakes Pipe Line Company.

Industrial and Chemical Sessions

In these sessions, 10 papers presented a variety of problems such as inspection of petrochemical plant construction, high voltage d-c testing of cables and fault locations; corona in metal-clad switchgear; electrical installations in Class I, Groups A and B, hazardous locations; expansion of electrical facilities; problems of power supply and purchased power in chemical plants; and motor control and insulation developments in the chemical industry.

Management Session

The problems of management were presented by three officers of Dowell, Inc., and

Courtesy T. W. Collins

AIEE President M. D. Hooven (*left*); William Weitzen, speaker at the General Session (*center*) and George A. Smith, Jr., General chairman (*right*) relaxing between sessions at the South West District Meeting.

Dr. H. H. Race, consultant manager, Development Education, General Electric Company. R. D. Ledbetter presided and W. W. Lynch, president, Texas Power and Light Company, acted as moderator.

The complexity and extensiveness of operations in Dowell, Inc., which is engaged in fracturing and gassifying to stimulate production of oil wells, was outlined by J. G. Staudt, executive vice-president. The second speaker on the panel was A. C. Polk, vice president and general manager, who explained how the corporation handled the problem of management through organization to meet the general objective of performing services and selling products. The third speaker, W. N. Estel, director of personnel, stated the value and importance of giving men creative dynamic responsibilities in which they can grow. The psychological tests employed are not infallable but they provide a good guide. Information is recorded so that people can improve themselves. With respect to the type of interviews the qualities looked for were general initiative, interests, motives, suitability to the organization, and possibility of advancement.

"Bedrock Foundations for Manager Development" were outlined in six phases—individuality, opportunity for personal growth, attention focussed on the man, attention focussed on the work and the business enterprise as a dynamic integrative unity, in an address by Dr. H. H. Race, General Electric Company. The full text of this article appears on page 534 of this issue of *Electrical Engineering*.

Entertainment

On Monday, April 2, a reception was given at the Baker Hotel, which afforded an opportunity to get acquainted, and was conducted by George Pingree, chairman of the Reception Committee.

Tuesday evening, a large number of members and guests attended the dinner-dance in the Terrace Room of the Baker Hotel. Music by an outstanding orchestra was enjoyed as well as a floor show.

During the meeting, the ladies were kept busy with a program arranged by Mrs. E. C. Thompson, chairman of the Ladies Committee. A suite was maintained for informal gatherings. Coffee was served each morning at which time a door prize was given. Monday morning, a get-acquainted coffee gathering was held in one of the ballrooms of the new Statler-Hilton Hotel. Tuesday morning, a brunch and fashion show took place in the Zodiac Room at Neiman-Marcus Department Store. Wednesday morning, the ladies went by bus to the Dallas Athletic Country Club for a book review and luncheon. Door prizes and individual favors were given at this function. In the afternoon, a tour of Dallas was taken in chartered busses.

Inspection Trips

Inspection trips were arranged to the Bell Aircraft Corporation, where the Model 47 Helicopter, used extensively by all branches of the services, is made. The Chance Vought Aircraft Company's plant was also visited. The Navy has recently granted this company a large contract to produce the *F8U-1* jet Crusader. Another trip was taken to Texas Instruments, Inc., which is well known for the development and production of transistors and other electronic components such as transformers, resistors, and capacitors.

A trip was also taken to the Parkdale Power Plant of the Dallas Power and Light Company, which is a modern outdoor type of plant with 202,000 kw capacity. Construction of a third unit of 125,000 kw is well under way. Other points of inspection were Haskill Avenue Toll Center of the Southwest Bell Telephone Company and the Republic National Bank Building.

EXHIBIT ENTRANCE, an actual airplane door, shows Jo Ann Johannsen and Patty Raffety, hostesses, who served visitors coffee and cookies on opening day, with Bill McClung, electrical engineer, and John Logan, city sales, all of Braniff International Airways, Dallas, Tex.

Exhibits

In keeping with the theme of the meeting, 60 exhibits, which proved very popular, were displayed on the Exhibition Floor of the Baker Hotel adjacent to the meeting rooms. Some 43 companies from New England to California displayed the latest air-borne electrical apparatus, components, and support items. A number of the exhibitors were well pleased because those attending could ask intelligent questions about the displayed products. The concensus was that the exhibitions contributed greatly to the success of the meeting and the outstanding attendance. The following is a list of the exhibitors:

General Electric Company, Dallas, Tex.

Micro-Switch Division, Minneapolis-Honeywell Regulator Company, Waterbury, Conn.

Cline Electric Manufacturing Company, Chicago, Ill.

Burndy Engineering Company, Norwalk, Conn.

Courtesy T. W. Collins

A PORTION of the aircraft exhibition floor. Among the many items of aircraft equipment exhibited were generators, motors, constant speed drives, switches, fuses, radio equipment, weather mapping radar, and lighting equipment.

Collins Radio Company, Dallas, Tex.

Grimes Manufacturing Company, Urbana, Ohio

Sundstrand Machine Tool Company, Rockford, Ill.

Sprague Electric Company, North Adams, Mass.

Earl Lipscomb Associates, Dallas, Tex.

Federal Telephone and Radio Company, Clifton, N. J.

Cutler Hammer Incorporated, Dallas, Tex.

The Garrett Corporation, Los Angeles, Calif.

Westinghouse Electric Corporation, Pittsburgh, Pa.

Wright Industrial Products, Dallas, Tex.

Spencer Thermostat Division, Metals and Controls Corporation, Attleboro, Mass.

Aircraft Marine Products, Inc., Harrisburg, Pa.

Micro-Pak Power Division, American Machine and Foundry Company, Colorado Springs, Colo.

Turbo Engineering Division, American Machine and Foundary Company, Pacoima, Calif.

Leland Electric Company Division, American Machine and Foundary Company, Dayton, Ohio

Potter and Brumfield Division, American Machine and Foundry Company, Princeton, Ind.

Chatham Electronics Division, Gera Corporation, Livingston, N. J.

George E. Harris and Co., Inc., Wichita, Kans.

Surprenant Manufacturing Company, Boston, Mass.

Thomson Engineering Service, Fort Worth, Tex., agent for:

Wesco Plastic Products, Venice, Calif.

Dakota Plastics Company, Compton, Calif.

Electro Mechanic Specialties Company, Los Angeles, Calif.

Spectrol Electronics Division, Carrier Corporation, San Gabriel, Calif.

Mason Electric Corporation, Los Angeles, Calif.

Control Products, Inc., Harrison, N. J.

Viking Electric Company, Canoga Park, Calif.

McColpin-Christie Corporation, Los Angeles, Calif.

Barber-Colman Company, Rockford, Ill.

Mycalex Corporation of America, Clifton, N. J.

Haydon Switch, Inc., Waterbury, Conn.

The A. W. Haydon Company, Waterbury, Conn.

Engineering Associates, Inc., Fort Worth, Tex.

International Electronic Research Corporation, Burbank, Calif.

Mag-Electric Products, Inc., Division National Aircraft Corporation, Hawthorne, Calif.

San Fernando Electric Manufacturing Company, San Fernando, Calif.

North American Phillips Company, Mount Vernon, N. Y.

Jack and Heintz, Inc., Cleveland, Ohio

The Superior Electric Company, Bristol, Conn.

Leach Relay Company Division, Leach Corporation, Los Angeles, Calif.

G. M. Giannini and Company, Inc., Pasadena, Calif.

Beech Aircraft Corporation, Wichita, Kans.

Cole Electric Company, Culver City, Calif.

Committees

Officers, and chairmen, and vice-chairmen of the committees which made the arrangements were as follows: S. M. Sharp; G. A. Smith, Jr.; P. S. Neblatt; O. S. Hockaday; John Hutchison; E. B. Robertson; C. A. Maas; J. B. Robuck; J. L. Pratt; P. G. Wallace; Felix Quirino; G. A. Dyer; Wendell Fowler; R. D. Ledbetter; J. R. Duff; J. C. Bibbs; H. L. Reynolds; C. F. Crandall; E. C. Wise; Curtis Musgrove; L. J. Blaize; E. W. Rogers; Mrs. E. C. Thompson; R. T. Martin; F. W. Tatum; Floyd McKenna; John Sandlin; and George Pingree.

Fort Wayne Host to Great Lakes District Meeting

THE FORT WAYNE SECTION was host to over 500 AIEE members, students, and guests at the Great Lakes District Meeting held at the Van Orman Hotel in Fort Wayne, Ind., April 16–18, 1956.

In addition to the General Session, there were 17 technical sessions held during the 3-day meeting. Luncheon addresses were presented by M. S. Coover, AIEE presidential nominee; M. D. Hooven, AIEE president; and Capt. Pierre Boucheron, U. S. Navy (Ret.).

Inspection trips were made to the Sorensen Station of the Indiana and Michigan Electric Company at Roanoke, Ind.; to the Inca Manufacturing Division and Indiana Rod and Wire Division of the Phelps-Dodge Copper Products Corporation; the General Electric Sound Laboratory; and the International Harvester Company Motor Truck Division.

Activities for the ladies included sightseeing tours and a tour of WKJG television studios, followed by a "Style Tea" at Wolf and Dessaurs, Fort Wayne's leading department store.

General Session

C. M. Summers, vice-president of District 5, presided at the General Session Monday morning. Following the Invocation by Rev. Phillip Fusco of the Fort Wayne Cathedral, R. E. Meyers, mayor of Fort Wayne, presented a short welcoming message to the members. Mr. Summers then introduced M. J. Carroccio, general chairman of the District Meeting Committee; D. J. Wartozk, chairman, Fort Wayne Section AIEE; M. D. Hooven, AIEE president; and N. S. Hibshman, AIEE secretary.

In the keynote address "Engineering Futures Unlimited," T. G. LeClair, AIEE past-president, discussed the increasing opportunities for engineers primarily from the point of view of advances in the fields of automation and nuclear energy. (The text of the address appears on page 501 of this issue of *Electrical Engineering*.)

Technical Sessions

At the various technical sessions, 68 papers were presented. Four sessions each were devoted to rotating machinery and power, three each to electronics and to transformers and stationary equipment, two to magnet wire and insulation materials, and one to professional development.

In the professional development session, G. E. Moore of the Westinghouse Electric Corporation presented "Industry Views the Electrical Engineering Curriculum," which states that an "optimum" undergraduate curriculum, in keeping with the objectives

Hazleton, Pa., Division Meeting

THE HAZLETON, PA., Division Meeting of the AIEE Lehigh Valley Section was held on April 13, 1956, at Genetti's Restaurant, Hazleton. C. T. Pearce, District 2 vice-president, gave an address on "Some Aspects of Atomic Power." Some Members attending the meeting were: *(left to right)* W. F. MacKenzie, AIEE Meetings and Papers Committee, Hazleton; C. A. Yanuzzi, underground System Engineer, PP and L Company, Allentown, Pa.; A. W. Plonsky, professor, University of Scranton, Scranton, Pa.; and S. S. Lesh, PP and L Company field test supervisor, AIEE Fellowship Committee. All items of electrical equipment shown on the table are at least 60 years old. They are: *(left to right)* bi-polar fan, bi-polar motor, station ammeter, hot wire ammeter, street light ammeter, cycle counter, hot wire voltmeter, Weston standard voltmeter, and bi-polar fan.

MEETING HIGHLIGHTS

Great Lakes District Meeting

Top: C. M. Summers, vice-president Great Lakes District, welcomes M. D. Hooven *(center)*, AIEE president, as *(left to right)* V. J. Warnock, Indiana and Michigan Electric Company; N. S. Hibshman, AIEE secretary; M. S. Coover, AIEE presidential nominee; J. Carroccio, general chairman of the Meeting; and Prof. E. T. B. Gross, Illinois Institute of Technology, look on. *Below left:* Members inspecting the General Electric Sound Laboratory during one of the two trips made to this Laboratory. *Below right:* At registration desk *(left to right)* Mr. Hooven; R. D. Jones, Advisory Committee; Mr. Warnock; Mr. Carroccio; J. M. Dills, Reservation and Registration Committee; R. H. Johnson, General Electric Company; and Anita Akers

of any given institution, must represent a compromise between "breadth" and "depth."

A paper presented by A. H. Spalding of Purdue University discussed some of the desirable qualities for those entering engineering colleges. Included are a proper standard of values, the ability of self-appraisal, an intense interest and desire for learning, an imaginative ability, and flexibility.

At one of the power sessions, M. A. Schultz of Westinghouse described the nuclear testing reactor being constructed by Westinghouse in Waltz Mill, southeast of Pittsburgh, Pa. This 20-mw reactor will provide a versatile facility for irradiation experiments that can be conducted under conditions of high flux, high temperature, and high pressure.

Another interesting power paper was "Load Characteristics and Their Effect on Distribution System Design" by H. E. Campbell of the General Electric Company. It was demonstrated that residence load characteristics established years ago are far from adequate for today's needs, in view of the increased use of home freezers, water heaters, air conditioners, and other major appliances.

A paper covering "hot-stick" maintenance of 330-kv lines was presented by H. T. Molden of Indiana and Michigan Electric Company in conjunction with an excellent color film showing linemen making repairs on the activated lines.

Several interesting papers were given at the sessions on electronics. "Glass in Electronics" by W. H. McKnight of Corning Glass Works described many of the new uses being made of glass in the electronic components field. Among these applications are precision parts, resistors, precision potentiometers, shields, coil forms, and capacitors.

W. D. Penn of Texas Instruments, Inc., presented a paper on high-frequency silicon transistor amplifiers. The methods used to compute power gain from measured transistor parameters were discussed together with the experimental verification of the results.

A paper, by R. W. Hall and R. N. McKnight of Phelps-Dodge Copper Products Corp., presented at a magnet wire and insulation materials session, described a new insulating material known as "daglas," practical for extremely high temperature operations. It is a combination of dacron and glass, fused together in manufacture and covered with silicon varnish.

"The Use of Aluminum in Dry-Type Specialty Transformers," by B. C. Biega of General Electric, was given at one of the sessions on transformers and stationary equipment. The paper deals with the problems and economics involved in the substitution of aluminum for copper in the transformer windings and terminal structures. The rapid increase in copper prices during the past year has been responsible for the emphasis on conversion to aluminum at this time.

Another interesting transformer paper was presented by Glenn Walters of General Electric concerning the application of a digital computer in the design of small transformers. In the specific line of transformers considered, it was estimated that 10 to 20 per cent of the design time was saved through use of the computer.

In one of the rotating machinery sessions, two papers by engineers of the A. O. Smith Corporation were presented describing a speed-torque curve tracer which displays an instantaneous plot of the speed-torque characteristic curve of a motor during acceleration or deceleration. The first, by Alex Paalu, is concerned with the indicator unit; the second, by K. J. Waldschmitt and H. P. Boettcher, covers applications and results.

AIEE Board of Directors Meeting Held in Dallas, Tex.

NINETEEN MAJOR TOPICS involving 40 items of business were considered at the meeting of the AIEE Board of Directors, held in Dallas, Tex., April 3, 1956. The following is an outline of some of the more important actions of the Board which are of immediate interest to the members of the Institute. Some of the topics discussed and acted upon by the Board are reported in greater detail elsewhere in this issue of *Electrical Engineering*.

Of the 27 members of the Board, 24 were

present for the all-day session in the middle of the South West District 7 Meeting. A District Meeting Luncheon was held in honor of the Board at which President Hooven made his principal address. The Board was also entertained by the officers of the Texas Power and Light Company whose facilities were used for the Board meeting. By formal resolution, the Board expressed its appreciation for all this hospitality, and its congratulations to District No. 7 on an outstanding meeting with a record registration (about 1,300), and on the pioneering of an exhibit as part of an AIEE meeting.

Membership

Additions to the membership were approved as follows: 9 Fellows, 153 Members, 567 Associate Members, 66 Affiliates, 749 Students. Biographical sketches of the newly elected Fellows appear in this issue.

The Constitution provides for the crediting of the record of a candidate for Fellow grade with years of membership in a cognate society in a grade equivalent to Member of AIEE. A number of foreign societies do not have membership grades. A resolution recommended by the Board of Examiners was approved as follows:

RESOLVED, that in the case of foreign societies having no membership grade equivalent to our Member grade, the Board of Examiners is not exceeding the intent of the Constitution by interpreting responsible positions in such societies, or honors, to be the equivalent of different grades of membership, and that the Board of Examiners in lieu of written qualifications for such positions or honors may accept instead the experience of the applicant or nominee on the date involved where such experience is equivalent to that required for our Member grade as a minimum.

Finances

The treasurer reported a balance in the General Fund as of February 29, 1956, of $321,922, as compared with $148,006 at the end of February 1955. The latter figure included $100,000 transferred from the reserve capital fund during February 1955.

During the depression of the 1930's AIEE provided an "exchange allowance" for foreign members which in most cases took the form of a 40 per cent discount on their membership dues. This has been continued ever since that time. On the basis of a report from an expert consultant, and the fact that no other major American engineering society allows such a discount, the Board voted to discontinue the practice, effective May 1, 1956.

The 1956–57 Budget was approved as presented by the Finance Committee. This budget calls for the expenditure of $1,636,500, including $35,969 to be "transferred to reserves." Income from dues and fees is estimated at $843,500. The largest item of expenditure is for publications, $790,051. An appropriation of $49,750 was approved for Public Relations.

Constitution and Bylaws

The Board of Directors approved amendments to the Constitution and Bylaws as follows: (*C*-means Constitution section, for vote by the membership in the spring of 1957; and *B*-means Bylaw section.)

B-71 To establish a sixth Technical Division to be known as the Instrumentation Division. This will be formed by the expansion of the present Committee on Instruments and Measurements.

B-16 As reported on page 290 of the March 1956 issue of *Electrical Engineering*, the Board approved the elimination of entrance fees for Corporate members and Graduates of the Institution of Electrical Engineers (British), who reside in the United States. (See page 563 of this issue of *Electrical Engineering* for details.)

C-56 and B-55 Extensive revisions and additions are to be made to the Constitution and Bylaws for the purpose of authorizing "Overseas Chapters" of AIEE. These organizations are to be largely informal, without vote or financial obligation. Otherwise they will follow the pattern of Section organization and activity. They will be recognized as part of the Institute organization and will be under the administration of District No. 3.

C-34, 35, and B-28 were revised to simplify the procedure of organizing the Committee of Tellers and to reduce the burden of their work in the event that the balloting for officers involves "no contest."

Final approval was given to the amendment by Bylaw *53* providing that total Section allotments will henceforth be paid by one check in October. As previously explained, financial reports from the Sections are no longer required and the previous provision calling for the reduction of allotments by the amount of unexpended balances in the Section treasuries has been deleted from the Bylaws.

The Chairman of the Committee on Constitution and Bylaws proposed, and the Board approved, the eventual rewriting of the Constitution and Bylaws in "handbook style." Amendments, revisions, and additions to the Constitution and Bylaws will, insofar as feasible, be written in this new format pending the re-editing of the complete documents.

Organization

The Committee on Planning and Coordination (P and C) presented broad recommendations for the extension of the Institute's activities and for the revision of its policy-making and administrative organization. A. J. Bergfeld of the firm of Stevenson, Jordan and Harrison, Inc., management engineers, discussed at length his firm's report, previously distributed to the Board, and answered questions of the Board members. The Board then proceeded to take the following steps in the direction of implementing the recommendations of the consultants and the P and C Committee:

RESOLVED that,

(1) A program for the further development of Technical Groups be approved, and that appropriate channels be provided in the organization of the Sections, Districts, and Administrative Committees of the Institute for their establishment and management; and in the organization of the Technical Committees and Divisions for their technical servicing.

(2) That the necessary steps be taken to provide for the Board of Directors the opportunity to concentrate its attention on the making and development of Institute policy, by delegating responsibility and authority for administration and operation to suitably constituted committees.

Technical Activities

On recommendation of the Committee on Technical Operations (CTO), the Board approved the participation of the AIEE in a proposed Nuclear Congress to be held in Philadelphia, Pa., March 10–16, 1957, under the general sponsorship of Engineers Joint Council and with participation by all engineering and scientific bodies able to make a contribution to the program. This is to be organized and operated on the general lines of, and in the light of the experience with, the Nuclear Congress held in Cleveland during December 1955.

Funds were authorized in the Budget for a survey of the needs and desires of the members, and the opinions of technical committeemen, past and present, relative to the technical program and activities of the Institute.

The Committee on Technical Operations reported that a special meeting will be held

Cleveland Section Banquet Committee

AIEE CLEVELAND SECTION banquet committee planning the 1956 Annual Cleveland Section Dinner Meeting. Elmer Lindseth, president of the Cleveland Electric Illuminating Company, was banquet speaker. The title of his address was "Electrical Living 20 Years from Now."

between the Fall and Winter Meetings for the purpose of presenting papers on the new Transatlantic Submarine Cable. The Institution of Electrical Engineers in London and the Engineering Institute of Canada in Montreal, Que., Canada, are to hold simultaneous meetings on the same subject.

The CTO also announced the formation of a new Joint Division Committee on Automation and Integrated Data Processing.

Sections and Branches

The Sections Committee recommended, and the Board approved, the following By-law revisions:

B-46 to provide that a minimum of 15 members must be included in a part of a Section territory before it shall be recognized as a Subsection and that no allotment shall be paid for a Subsection the membership of which has fallen below 10 or which has held less than 4 meetings in the fiscal year.

B-49 to raise the minimum Section membership from 30 to 40. Other provisions to remain the same.

The Board approved and made the necessary appropriation for the production of a Section Operations Manual. This document, as prepared by Director R. E. Kistler of Seattle, Wash., is now in the process of revision and editing by the Sections Committee. It is hoped that it will be ready for distribution at the Delegates Conference at San Francisco, Calif.

Approval was given to the establishment of an Affiliate Branch at the University of Buffalo, Buffalo, N. Y.

New Building

The Special Task Committee of 15 representatives of the Five Societies, for the selection of a site for the proposed new Engineering Societies Center Building, reported progress and expressed the expectation of having a report ready before the first of July.

Two Student Engineers Awarded Fortescue Fellowships

The award of Charles LeGeyt Fortescue Fellowships to two young electrical engineers has been announced by N. S. Hibshman, secretary of the AIEE. G. E. Moore, of Pittsburgh Pa., is chairman of the committee administering the award for the Institute.

The fellowships, which provide $2,000 each for graduate study, were made to Daniel F. Fox, Jr., 25, of 471 Robinson Court, Pittsburgh, Pa., and Kenneth F. Steffan, 21, of Poplar Bluff, Mo.

Mr. Fox is a student at the University of Pittsburgh, where he expects to receive his degree of bachelor of science in electrical engineering in June 1956.

Mr. Steffan is a senior at the Missouri School of Mines, majoring in electrical engineering.

The fellowship was established in 1939 by the Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation) as a memorial to Charles LeGeyt Fortescue for his contributions to the electric power industry.

Dr. Fortescue, who was graduated from Queens University, Kingston, Ont., Canada, as the university's first electrical engineer in 1898, received 185 patents on electrical inventions during his 38-year career with Westinghouse.

D. F. Fox

K. F. Steffan

Mr. Fox has an outstanding scholastic record, standing first in his class of 50, with a quality point average of 2.933 out of a possible 3.000. He was graduated from the U. S. Navy Instructor Training School on January 16, 1953, standing first in a class of 12; and from the U. S. Navy Tradesman (Training Devices Specialist) in 1952, standing first in a class of 22. He attended Marquette University from September 1949 to March 1950.

His extracurricular activities include a summer as assistant for the Mellon Institute of Industrial Research, undergraduate assistant for the University of Pittsburgh Radiation Laboratory, technician for the Atomic Power Division of Westinghouse Electric Corporation, and machine operator of the National Works of the U. S. Steel Company.

He is an active student member of the AIEE, the Institute of Radio Engineers, and the Instrument Society of America. He is also a member of Eta Kappa Nu, Sigma Tau, and other fraternities. He has received the Outstanding Senior Award for February 1956 and the University of Pittsburgh "E" Award, given to an engineering student sponsored by the University to work in Europe during the summer.

Mr. Steffan is a native of St. Louis, Mo. He was valedictorian of the graduating class of Poplar Bluff High School in 1952. He was an assistant operator for the Missouri Utilities Company during the summer of 1952 before entering the Missouri School of Mines (MSM). During the summers of 1953 and 1954 he was again employed by the Missouri Utilities Company at Popular Bluff. Last Summer he was employed by the Sperry Gyroscope Company, Great Neck, N. Y., as an engineering aide in a research and development group engaged in the development of traveling-wave tubes and general microwave research. He has been elected to membership in Sigma Pi Sigma, Eta Kappa Nu, Tau Beta Pi, and Phi Kappa Phi. At present he holds the position of station manager of the MSM Radio Club. He received the sophomore physics achievement award and has held the Schlumberger collegiate award for the past two years.

EJC Annual Report Published

The 1955 Annual Report of the Engineers Joint Council (EJC) has been published. EJC, which was created in 1952, is made up of the following constituent societies: AIEE, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Water Works Associa-

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until June 26. Duplicate double-spaced typewritten copies of each discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before June 26.

56-30 **The Pulse Stretch Coupling Circuit.** *H. W. Patton*

56-207 **A Single-Transistor Magnetic-Coupled Oscillator.** *Kan Chen, A. J. Schiewe*

56-229 **Magnetic Frequency Multipliers and Their Rating. Part I. Frequency Triplers.** *W. McMurray*

56-276 **Temperature Stabilization of Transistor Amplifiers.** *L. M. Vallese*

56-440 **Negative Sequency Voltage Detection on Aircraft A-C Electric Systems.** *R. D. Jessee, P. F. Boggess*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th Street, New York 38, N. Y.

ORGANIZING COMMITTEE of the Merrimack Valley Subsection, Lawrence, Mass., (*seated left to right*) L. C. Jutras, New England Power Service Company; P. Chonlian, Western Electric Company; C. N. Cleary, Western Electric Company; C. E. Chapman, Lawrence Electric Company; G. Frost, Lawrence Electric Company; R. V. Bowser, New England Power Service Company; (*standing left to right*) M. Manzi Jr., Manzi Electrical Corporation; A. P. Manzi, Manzi Electrical Corporation; R. N. Campaigne, Western Electric Company; F. R. Stansel, Bell Laboratories; W. J. Eckel, New England Power Company; R. W. Allen, Lawrence Electric Company; R. W. Smith, Lowell Electric Light Corporation; P. D. Black, New England Power Service Company; and K. E. Gordon, New England Power Service Company.

tion, Society of Naval Architects and Marine Engineers, American Society for Engineering Education, American Society of Refrigerating Engineers, and the American Institute of Chemical Engineers. The Annual Report is divided into four parts: Activities of 1955, Constitution and Bylaws, Committees for 1956, and Directory. Prominent among the committee reports contained in the first section is the report of activities and accomplishments of the Engineering Manpower Commission (EMC). Since its establishment in 1950, the program of the EMC has been based on the following goals: to aid in maintaining the supply of engineers; to promote the most effective utilization of engineers in maintaining the national health, safety, and interest; and to aid in establishing the importance of the engineering profession to the national economy.

Lawrence, Mass. Subsection Organized

AIEE activities were extended to another New England community on Monday, April 23, 1956, when 50 engineers gathered for the first AIEE technical meeting in Lawrence. Sponsored by the Lynn Section, this meeting laid the groundwork for a Merrimack Valley Subsection, for which a formal petition has been made by AIEE members in the area. Heading the Subsection organizing committee was C. N. Cleary of the Western Electric Company, Lawrence.

F. O. MacFee, vice-chairman of the Lynn Section, explained that the Subsection would become operative upon election of officers. A Nominating Committee is preparing a slate of candidates, and another committee is preparing a set of bylaws. The Organizing Committee expects this Subsection to be in operation by next fall.

The meeting speaker was P. E. McGuinness, of The United Shoe Machinery Corporation, whose subject was "Automation."

French Scientific and Technical Book Exhibit

Some 250 French scientific and technical books will be exhibited at the Engineering Societies Library, 29 West 39th Street, New York, N. Y., during June 1956. Engineers, educators, scientists, and researchers will be able to browse through selected books made available by the Cultural Division of the French Embassy, New York, N. Y., through the co-operation of the leading publishing firms in France.

There will be books in the fields of civil, chemical, electrical, mechanical, and mining and metallurgical engineering; industrial physics; and mathematics, physics, and the earth sciences. One of the purposes of the exhibit is to keep American engineers, engineering educators, and researchers in-

New York Section Tours GE Switchgear Works

MEMBERS AND GUESTS of New York Section, Power and Industrial Division, watch graphic demonstration of results of overloading and obsolescence of switchgear before taking guided tour of General Electric (GE) Company's Philadelphia, Pa., switchgear works and new high-voltage, high-capacity testing laboratory. Sixteen stationary and eight roving guides were provided with exact routes and timetables in order to cover high points of switchgear manufacture and testing on the all-day inspection trip held April 20. Arrangements by W. B. Shields (AM '48); T. H. MacCauley (AM '45), GE.

formed of the advances made by their French colleagues.

The exhibit will be held in the Reading Room of the Engineering Societies Library which, during June, will be open Mondays through Saturdays, from 10 a.m. to 5 p.m.

San Diego Section Members Tour Aircraft Carrier

A recent activity of the Aviation Technical Division of the AIEE San Diego Section consisted of a tour of the aircraft carrier *USS Bon Homme Richard* (*CVA-31*). This tour was conducted in two basic sections, in which groups of 10 men each were conducted personnally by either a qualified officer or chief petty officer through various ship installations.

For those members of the group who had security clearances on file at the Naval Air Station, San Diego, Calif., there was a classified area tour; for those who did not have clearances on file, there was a tour of various unclassified areas. Those in the classified area tour were able to see the combat information center and various radar installations. Among those areas visited by all groups were the captain's bridge, and the flight operation center. During the tour, the group inspected the *Mark 7* arresting gear and steam catapult facilities. They also viewed anti-aircraft facilities, and unclassified electronics and electrical shops aboard the carrier.

The trip was very well attended and received by the members who greatly appreciated the courtesy extended to them by the Navy personnel.

AIEE Women's Auxiliary Presents Gift to Swarthmore College

On March 14, 1956, Mrs. W. F. Henn, chairman of the AIEE Philadelphia Section Women's Auxiliary, presented a check for $300 to John McCrumm (M '47), chairman of the Division of Engineering at Swarthmore College, Swarthmore, Pa.

The money was used to purchase a Z-angle meter, a piece of electronic equipment for precision measurements.

The Women's Auxiliary, composed of wives, mothers, and sisters of AIEE members, was organized in 1948 with 15 members. The present membership is well over 200.

For the past two years the Auxiliary has given a card party at the Engineers' Club of Philadelphia to raise money to purchase a piece of electrical equipment to be presented to one of the colleges in the Philadelphia area.

Engineers Hold Instrument Conference in Boston

Some 500 engineers whose main technical interest is the vast array of instruments that control today's intricate industries, gathered Thursday, April 26, in the Hotel Bradford, Boston, Mass., for a two-day conference on the latest developments in their field. The conference, sponsored by the AIEE, The American Society of Mechanical Engineers, and the Instrument Society of America, was titled "New Developments in Instrumentation for Industrial Control."

MEMBERS AND GUESTS of Aviation Division, AIEE San Diego Section, on bridge of *USS Bon Homme Richard* (*CVA-31*), during inspection tour.

Highlights of the conference were sessions on display and recording, automatic data handling systems, advanced instrumentation systems in industry, and computer controlled systems for industry.

The sessions held on April 26, were on the human bottleneck in data systems, the dynamics of self-balanced systems, recent developments in information display and recording, modern scanning, monitoring, display, and circuitry techniques in plant data systems.

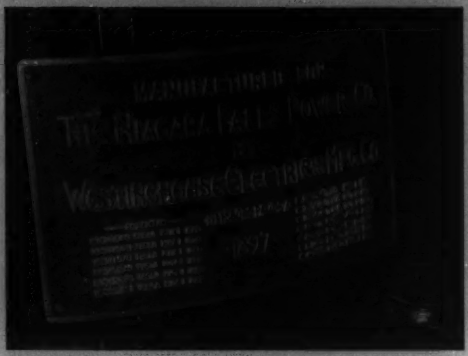
The remainder of the program included sessions on data systems in the atomic, aircraft, chemical, and electric power systems, and control advances in computers.

At a banquet in the Bradford Thursday evening, the principal speaker was Dr. J. J. Grebe, director of nuclear research and development for the Dow Chemical Company. Dr. Grebe's address was entitled "Horizons in Instrumentation," which covered three types of controls that can be coupled together to provide complex information quickly and accurately.

Edison Electric Institute To Hold Annual Convention

The 24th Annual Convention of the Edison Electric Institute will be held in Atlantic City, N. J., June 4–6. In keeping with the spirit of the 1956 Convention theme,

MEMBERS of the Philadelphia Section Women's Auxiliary and members of the Swarthmore College staff, receiving a gift from the Auxiliary, are: (*left to right*) Howard Jenkins, chairman of the department of electrical engineering; Mrs. S. H. Farace, treasurer of the Auxiliary; Mrs. C. T. Pearce, junior past chairman; Mrs. W. O. Mascaro, vice-chairman; Mrs. W. N. Gittings, chairman of Ways and Means Committee; Mrs. J. M. Alter, chairman of Membership Committee; Mrs. W. F. Henn, chairman of the Women's Auxiliary (presenting the check), and John McCrumm, chairman of the Division of Engineering of Swarthmore College.



NAMEPLATE on one of the first generators (5,000 HP) installed at Niagara Falls Power Company, now Niagara Mohawk Power Corporation, showing Nikola Tesla as holder of nine patents listed.

"Tell Our Story—Go Forward! Clearing and Widening the Expressways of Electric Power! For America!" the Convention Program Committee, headed by N. B. Gussett (M '37, F '48), president of Iowa Power and Light Company, is arranging a program of exceptional quality and diversity.

In the five business sessions of the Convention, nationally recognized authorities in the fields of finance, manufacturing and selling, labor, law, legislation, and public attitude will join with leaders of the electric industry in a sequence of addresses that promise to be of great interest. The first General Session will be held Monday afternoon, June 4; the second and third on Tuesday; and the fourth, and fifth on Wednesday, June 6.

AIEE Members Honor Nikola Tesla

On April 5, members of the Niagara International Section of the AIEE toured the Edward Dean Adams Station, Niagara Falls, N. Y., in commemoration of the one hundredth anniversary of the birth of Nikola Tesla (AM '88, F '17), inventor of the system of a-c power transmission which revolutionized industrial power transmission. The tour was conducted during the afternoon. Following dinner served in the La Salle Yacht Club, the group heard G. H. Dales, administrative assistant in the system project engineering department of the Niagara Mohawk Power Corporation, speak on the Niagara Mohawk Adams Station where Mr. Tesla's polyphase a-c system was first put to practical use.

Today, nearly all electricity in the world is generated, transmitted, distributed, and turned into mechanical power by means of the Telsa system. He is credited with the greatest single group of inventions in the field of electrical engineering.

Plans Announced for 1956 National Electronics Conference

More than 100 technical papers and 235 commercial exhibits will be featured at the 12th annual National Electronics Conference, to be held in Chicago, Ill., October 1–3, at the Hotel Sherman.

A record attendance of 10,000 is expected at the three-day meeting which is sponsored each year by the AIEE, Institute of Radio Engineers, Illinois Institute of Technology, University of Illinois, and Northwestern University.

Also participating in the conference are Michigan State, Purdue, Michigan, and Wisconsin Universities, Radio-Electronics-Television Manufacturers Association, and Society of Motion Picture and Television Engineers.

R. R. Jenness (AM '44, M '51), assistant professor of electrical engineering at Northwestern University, has been elected president of this year's conference.

MEMBERS OF THE Niagara International Section of the AIEE at the Niagara Mohawk Power Corporation the first station to be built purely for power instead of light.

Additional Conference Papers Now Available

The following is the list of conference papers presented at the 1955 Southern District Meeting, Middle Eastern District Meeting, Pacific General Meeting, and Fall General Meeting, which were not numbered at the time of the meetings. They have now been numbered and are available to members for 40¢, and to nonmembers for 80¢. Send order and remittance to: AIEE Order Department, 33 West 39th Street, New York, 18, N. Y.

Southern District Meeting, April 13–15, 1955, St. Petersburg, Fla.

DP55-359 Shocks from Southern Industry. *B. R. Askew*
360 Continuous Demand Metering. *R. J. Owens*
367 Introduction to Feedback Control Systems. *A. R. Eckels*
368 Magnetic Amplifier Instrument Servomechanism. *J. F. Koenig*
372 New Developments in Connectors for Aluminum. *Richard Harap*
373 Integrating Amplifier Broaden Field for Application of Electric Drives. *C. D. Beck*
375 The Use of Magnetic Amplifiers in the Paper Industry. *S. J. Campbell*
376 A Comparison of Variable Speed Drives of Small and Medium Horsepower and Their Application in the Paper Industry. *W. H. Buford, G. E. Shaad*
377 The Gas Turbine in Southeastern Pulp and Paper Mills. *F. Wierk, W. L. Garlington*
383 Insulation Characteristics of Wood and Porcelain in Series. *J. M. Clayton, D. F. Shankle*
384 Steel Tower Transmission Line Design and Construction. *C. B. Benham*
387 Type 45 Universal Carrier Equipment. *R. R. Sanders*
388 Outside Plant Considerations with High Frequency Carrier Systems. *J. N. Petrie*
389 Solving Noise and Crosstalk Problems with Compandors. *T. B. Collins*
390 Electrical Maintenance-Phosphate Mining and Flotation. *J. L. Cox*
392 Grounding System Practices in Florida Phosphate Industry. *W. Barbarowicz*
393 Performance Characteristics of High-Voltage Rubber-Insulated Cables. *S. J. Rosch*
394 The Problems and Methods of Automatically Computing Toll Calls. *J. D. Canfield*
395 The Tampa Area Intertoll Switching System. *R. W. Jones*
403 Some Lightning Arrestor Application Factors. *J. E. Barkle, T. J. Bliss*
404 The New Thyrite Magne-Valve Line-Type Arrestor. *W. H. Eason, J. H. Snell, A. A. Olsen*
405 Relay and Fuse Protection of Tapped Transmission Lines. *C. W. Cogburn*
406 Cathodic Protection in Power Plants. *J. B. Prime, Jr.*

Lamme Medal 1956 Nominations Due December 1

Special attention is directed to the fact that the names of Institute members who are considered eligible for the AIEE Lamme Medal, to be awarded early in 1957, may be submitted by any member in accordance with section 1 of Article VI of the bylaws of the Lamme Medal Committee as follows:

"The committee shall cause to be published in one or more issues of *Electrical Engineering*, or of its successors, each year, preferably including the June issue, a statement regarding the Lamme Medal and an invitation for any member to present to the Secretary of the Institute by December 1, the name of a member as a nominee for the medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in co-operation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified in the foregoing quotation.

Article V, section 2, specifies that: "The committee in making the award shall carefully observe the limitation imposed by Mr. Lamme, that the recipient must have 'shown meritorious achievement in the development of electrical apparatus and machinery.' This shall be taken to mean that the meritorious achievement must be of such character that it has resulted or will result in the production of substantially improved electrical apparatus or machinery. Any work which meets this requirement is admissible whether it be (a) in development of the theory involved; (b) in development of the characteristics of the materials employed; (c) in development of over-all design; or (d) in development in other ways which results in substantial improvement in electrical apparatus or machinery. The words 'electrical apparatus or machinery' shall be taken to indicate discrete and self-contained devices which may or may not include mechanical moving parts without limitation as to the field of application. They shall not be taken to include transmission or distribution systems as a whole, but rather to include the apparatus and machinery that is used in making up such systems."

DP55-410 Color Television—Its Progress, Its Problems, Its Promise. *L. R. Fink*
411 Microwave as a Medium for Electric Utility Relaying. *N. B. Thorp*
413 Objectives, Utilization and Instrumentation of the Raleigh Research Reactor. *H. A. Lamonds*
422 Can Manufacturing in Florida. *F. W. Gaylord*
423 The Application of Computers for Power System Operation. *C. Nichols*
424 Single-Phase Line Operation of Three-Phase Motors. *H. T. Smith*
425 Modern Cable Insulations for Communication and Power. *P. H. Ware*

Middle Eastern District Meeting, May 4–6, 1955, Columbus, Ohio.

DP55-314 Insulation Application of Modern Power Transformers. *G. W. Clothier*
293 Research Tools for the Development of Atomic Power. *S. L. Fawcett*
294 The Present State of Power Reactor Development. *W. K. Davis*
296 A New Development in Retinal Photography. *J. H. Prince, John Cowan, N. A. Smith*
298 Telefax Patron Switching. *W. B. Lloyd*
299 Rigorous Determination of the Capacitance and Characteristic Impedance of UHF Coaxial Rectangular Transmission Lines. *T. J. Higgins, J. Skiles*
301 Solutions to Unreliability in Complex Electronic Equipment. *G. H. Sheer*
304 Nuclear Power Reactor Control. *J. J. Stone*
305 Opportunities for Education in Nuclear Engineering. *C. E. Dryden, G. B. Carson*
310 Calculations of A-C/D-C Resistance Ratios for Stator Conductors. *D. S. Babb, J. E. Williams*
311 A Grass Roots Telephone Man Looks at Research and Manufacturing. *G. W. Searle*
324 Application of Electronic Computers to Flood Routing and Other Hydraulic Problems. *E. Lawler*
DP55-326 Design Studies of Large High Performance Pressure Control Systems Using Analogue Computer. *G. Rossolis*
327 Simulation of Mechanical Systems Coupled by Cams and Levers. *J. J. Stone, W. Hesse, J. K. Weatherbee*
328 Magnet Wire Performance in Product Life Tests. *R. L. Balke*
329 Insulation Evaluation Program and Equipment Used for Medium-Sized Electric Machinery. *G. L. Moses, R. D. Wolford*
331 The End Point in Motorette Testing. *G. A. Cypher, T. J. Gair*
332 Economic Study of Higher Voltages. *P. L. McEvan, J. G. Tarboux*
333 Use of Higher Secondary Voltages in Commercial Areas. *R. F. Lawrence*
340 Calculation of Impedance-Frequency Characteristics of Induction Motor Rotor Conductors. *J. E. Williams*
341 The Role of Economics in System Planning. *Abraham Gerber*
342 Planning the Power System I—General Considerations. *T. J. Nagel, C. A. Imburgia*
343 Planning the Power System II—Examples of Technical Problems. *C. F. DeSiano*
344 Economic System Loading. *G. W. Stagg*
345 Co-ordination Problems in A-C Systems. *H. K. Omer*
347 Special Analogue Computer. *G. D. McCann*

Pacific General Meeting, August 15–17, 1955, Butte, Mont.

CP55-655 Minimum Cost Loading of Transformers. *Arthur Kloppenstein*
660 Automatic Reclosure—Operating Experience on the Pacific Coast. *Report of the Pacific Coast Subcommittee, of the Committee on Relays*
657 Where Do We Go from Here? *L. M. Peoples*
651 An Excited Voltage Regulator for Environmental Free Aircraft Alternators. *R. V. Evans*
645 Modern Electric Mine Haulage Equipment. *J. W. Brauns*

Future AIEE Meetings

Summer and Pacific General Meeting*
San Francisco, Calif.
June 25–29, 1956

AIEE-IRE-ISA Telemetering Conference
Ambassador Hotel, Los Angeles, Calif.
August 20–21, 1956
(*Final date for †TP—closed, ‡CP Syn.—June 5, CPMs—June 15*)

AIEE-IRE Industrial Electronics Conference
Hotel Manager, Cleveland, Ohio
September 24–25, 1956
(*Final date for †TP—June 27, ‡CP Syn.—July 12, CPMs—July 20*)

AIEE-IRE-RETMA National Electronics Conference
Chicago, Ill.
October 1–3, 1956
(*Final date for †TP—July 3, ‡CP Syn.—July 19, CPMs—July 27*)

Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 1–5, 1956
(*Final date for †TP—June 4, ‡CP Syn.—July 19, CPMs—July 27*)

AIEE-IRE Conference of Magnetism and Magnetic Materials
Hotel Statler, Boston, Mass.
October 16–18, 1956
(*Final date for †TP—July 19, ‡CP Syn.—Aug. 3, CPMs—Aug. 13*)

AIEE-IRE-ISA Conference on Electronic Technology in Medicine and Biology
Gov. Clinton Hotel, New York, N. Y.
November 7–9, 1956
(*Final date for †TP—Aug. 10, ‡CP Syn.—Aug. 24, DPMs—Sept. 4*)

AIEE-IRE Eastern Joint Computer Conference
Hotel New Yorker, New York, N. Y.
December 10–12, 1956
(*Final date for †TP—Sept. 12, ‡CP Syn.—Sept. 26, DPMs—Oct. 5*)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 21–25, 1957
(*Final date for †TP—Oct. 24, ‡CP Syn.—Nov. 8, CPMs—Nov. 16*)

North Eastern District Meeting
Pittsfield, Mass.
May 1–3, 1957
(*Final date for †TP—Feb. 1, §DP Syn.—Feb. 15, DPMs—Feb. 25*)

Middle Eastern District Meeting
Dayton, Ohio
May 7–9, 1957
(*Final date for †TP—Feb. 8, §DP Syn.—Feb. 22, DPMs—March 5*)

Summer General Meeting
Montreal, Que., Canada
June 24–28, 1957
(*Final date for †TP—March 26, ‡CP Syn.—April 11, CPMs—April 19*)

*Final date for submitting papers—closed
†TP—Transactions paper
‡CPSyn.—Conference Synopsis
CPMs—Conference Manuscript
(The CPSyn. date is 10 days before the CPMs date)
§DPSyn.—District Synopsis
DPMs—District Manuscript
(The DPSyn. date is 10 days before the DPMs date)

Paper and Pulp Industry Subcommittee

Courtesy University of Florida

THE PAPER AND PULP Industry Subcommittee of the Committee on General Industry Applications at a luncheon meeting held during the Conference on Electrical Engineering as Applied to the Paper and Pulp Industry, March 8–9, Gainesville, Fla. (*left to right*) E. K. Murphy, Rayonier Inc.; E. H. Overby, Union Bag and Paper Company; M. J. Osborne, Bowaters Southern Paper Corporation; R. R. Dirksen, Dynamatic Division, Eaton Corporation; H. M. Reed, International Paper Company; G. E. Shaad, General Electric Company; G. I. Burner, vice-chairman, Rust Engineering Company; S. A. Bobe, chairman, Westinghouse Electric Corporation; R. A. Jamison, Reliance Electric Company; V. S. Oakes, Hammermill Paper Company; S. A. Staege, Black Clawson Company; R. C. Berger, General Electric Company; S. J. Campbell, secretary, Westinghouse Electric Corporation; C. H. Hudson, General Electric Company.

CP55-656 The Growth of Safety Features in the Control of Electric Locomotives for Underground or Industrial Use. *Allen McLanahan*

648 Microwave, a New and Powerful Tool for Electric Utility Operation. *T. A. Combellick*

654 A New Recording Method for Color TV Using Black and White Film. *W. L. Hughes*

647 Harmonic Measurements on Television Transmitters. *W. S. Byers*

662 Design of Electronic Equipment for Radio Interference Reduction. *H. M. Sachs, A. L. Albin*

659 Satellite and Booster Station Allocation Developments. *O. W. B. Reed, Jr.*

664 Experience in Receiving and Rebroadcasting UHF Television Signals. *J. B. Wathinson*

CP55-663 Community Television Antenna Systems. *A. S. Taylor*

650 Electrical Installations and Safety Precautions Used in Underground Mining Operations. *W. R. Duffy*

644 Milliamperes Can Kill You! (A demonstration of low-voltage electric shock hazards.) *M. L. Bassett, B. A. Gurney, T. M. C. Martin*

Fall General Meeting, October 3–7, 1955 Chicago, Ill.

780 Cine-Radiography with Image Amplification. *F. J. Euler, P. A. Virbal*

Connecticut Section Prize Winners

THE PRIZE PAPER Meeting of the Connecticut Section of AIEE was held April 3, at the Convention Hall of the General Electric Company, Bridgeport, Conn. Section Chairman M. B. Sprague of The Southern New England Telephone Company congratulates (*left to right*) T. H. Rogers, manager of engineering, Machlett Laboratories, Springdale, winner of the second prize; Fred Heller, engineering manager, Burndy Engineering Company, Norwalk, winner of third prize; and J. C. Carroll, rubber power cable engineer, General Electric Company, winner of first prize.

CP55-772 Engineering Progress in the Design of Rotating Anode X-ray Tubes. *R. W. Cobaugh*

776 Factoring the Human Equation into Electrical Testing. *C. R. DeRosmer, H. E. Vana*

800 Serviceableness of Flexible Cord from the Standpoint of Safety to Life and Property. *F. V. Paradise*

773 The Grounding of Electrical Equipment in Farm and Rural Occupancies. *O. K. Coleman*

786 Characteristics and Ratings of Electric Motors for Drills in Mines. *Ben Harbage*

816 Effect of Voltage Variations on Mining Machine Motor Performance. *Frank Terrant, F. R. Hague*

798 A-C Drives for Mine Belt Conveyors. *W. R. Morton*

818 Square Loop Materials for the Timing of Multivibrators. *H. J. Venema*

810 The Ferroresonant Trigger Pair: Analysis and Design. *C. F. Spitzer*

817 Practice of Fault Location in the Boston Edison Company. *D. F. Tulloch*

813 Fault Location Methods. *R. F. Stevens, T. W. Stringfield, L. R. Spaulding*

796 Detection and Significance of Flaws in Traction Gearing. *J. B. McPherson, Mr. Brucknicki*

824 Maintenance Inspection of Traction Motor Gears and Pinions. *M. C. Winstanley*

778 High Potential D-C Testing of Insulation. *M. C. DuBois*

792 Color Television in Medical Education. *Michael Klein*

766 Closed Circuit Television in the Bell System. *C. A. Bartlett*

769 The Use of Television by the Biological Research Organization—Pilot Study. *M. C. Brown*

797 Closed Circuit Television at the State University of Iowa. *C. H. Menzer*

779 High Intensity Color Television for Very Large Screen Projection. *C. L. Ellis*

765 New High Capacity Service Entrance Protector for Industrial and Commercial Buildings. *L. L. Baird, V. N. Stewart*

770 General Circuit Theorems of Power Flow in Linear Networks. *J. F. Calvert, T. W. Sze*

802 Guide for Application of Arc Furnaces on Power Systems. *Preliminary Report by Working Group on Arc Furnaces*

774 A New 18-Inch Wide Continuous Web Facsimile Recorder. *A. G. Cooley*

809 Applications of a Frequency Shift Carrier Telegraph System in the Telephone Plant. *C. W. Smith*

764 A New Semiautomatic Teletypewriter Message Relaying System. *R. J. Anspach, P. A. Tomasi, J. T. Noiwinter*

822 The Technician—His Training and His Role in Industry. *E. A. Williford, W. W. Wood*

790 The Graduate Engineer—His Training and His Full Utilization in Industry. *S. B. Ingram*

777 Developments in Communications in the Lower St. Lawrence Valley. *F. C. Douk*

785 Motor Generator Battery Charging. *J. K. Haggerty*

807 Nickel Cadmium Batteries in Industrial Service. *O. S. Sandburg*

789 Internal Resistance Short Circuit Current and Other Lead Acid Battery Characteristics. *E. A. Hoxie*

784 Rotating Battery Charges in Railway Service. *W. R. Gwatt, K. H. Gordon*

821 Metallic Rectifier Battery Charging. *W. Warburton*

794 Frequency Shift Carrier for Distance Relaying. *H. W. Lamper*

803 Standards for Carrier Radiation. *Project Subcommittee No. 8 of the Committee on Carrier Current*

783 Problems in Evaluating Arc Resistance of Insulating Materials. *L. J. Goldberg*

795 A New Broad Band Microwave Antenna System. *A. S. May, R. W. Friis*

791 Squirrel Cage Motor Characteristics Useful in Setting Protective Devices. *F. R. Karr*

801 Factors Influencing the Starting Duty of Large Induction Motors. *V. J. Picozzi*

805 The Rigorous Solution of a Field Problem by Means of the Card Programmed Calculator. *L. Rabius, J. R. Faillace*

767 Problems of Applying Thermal Protection to Motors. *J. M. Bisbee*

799 Motor Protection for Steam Power Stations with 4-Kv Grounded Neutral Systems. *W. F. Wolf, S. H. Horowitz, R. B. Squire*

768 Protecting Motors with Low-Voltage Air Circuit Breaker Series Trips. *F. P. Brightman, P. J. Reifschneider*

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Telegraph Systems (R. B. Shanck, *Chairman;* C. H. Cramer, *Vice-Chairman;* V. N. Vaughan, Jr., *Secretary*). During the past year, the Telegraph Systems Committee sessions and technical papers have reflected increased interest and activity in facsimile, in teletype applications, in integrated data processing, in higher speeds of teletype transmission, and in the application of transistors and other new-art techniques. The Printing Telegraph Subcommittee held two meetings and completed preliminary work with respect to tolerances which it is felt could be applied to printing telegraph apparatus. At the present time, work is proceeding on a study relative to the methods of tests and the test circuits and apparatus which should be used in determining operating margins.

Power Division

Committee on Carrier Current (L. G. Eaton, *Chairman;* G. E. Farmer, *Vice-Chairman, East;* L. E. Ludekens, *Vice-Chairman, West;* J. L. Evans, *Secretary*). The Microwave Subcommittee sponsored a symposium at the Winter General Meeting. The attendance and lively discussions are indications of the interest in this subject. Technical sessions proposed by the Committee in the coming year are expected to emphasize microwave. The Committee on Carrier Current has drafted a revised scope which will more definitely state its responsibility in the microwave field. The new scope is now being processed through the usual approval channels. The Methods of Measurement Subcommittee has a long-term project. From the results obtained, it is expected that preferred procedures can be set up for obtaining carrier frequency characteristics of power and carrier equipment. The subcommittee is having difficulty in obtaining measurement data from the field, as the people making measurements are often too busy to report results.

Committee on Insulated Conductors (M. W. Ghen, *Chairman;* L. E. Fogg, *Vice-Chairman;* F. M. Hull, *Secretary*). The 3-year, $65,000 study of thermal resistivity of soils is now under way at Princeton University under the direction of Dr. H. F. Winterkorn. A more detailed knowledge of the mechanics of heat transfer from cables to surrounding earth, as well as conduction through earth, will be of interest to all who operate underground power cable systems. Investigation of insulating materials for extra high voltage cables is being actively pursued. This is a forward looking activity which, it is hoped, will contribute to other activities being conducted outside the institute in the realm of cable voltages in the 300 kv to 400 kv range. Increasing use of aluminum sheathes will result in studies to determine the factors which are important in the application of this type of cable to modern power systems to provide economical trouble-free life. The operation of buried distribution cables is being reviewed for possible increased use outside heavy density load areas. An interesting feature of this study is the establishment of the relation of service reliability to depth of burial.

Committee on Transformers (J. R. Meador, *Chairman;* D. L. Levine, *Vice-Chairman;* J. H. Chiles, Jr., *Secretary*). At the Committee meeting in Cleveland on April 11, reports of the seven Subcommittees were given and discussed. Work is being continued to supply material for inclusion in ASA *C57* in the new format. Additional dielectric test tables have been approved by the Committee and the remaining required tables are nearing completion. A proposed test code for power factor testing of mineral-oil-filled instrument transformers will soon be ready for letter ballot. Material is being gathered for the preparation of an impulse testing guide, and a working group has been established to bring up to date the impulse testing procedure in the new American Standards Association (ASA) Power and Distribution Transformer Test Code. A group is actively working on a study of the adequacy of present dielectric tests on transformer bushings. Progress is being made in the area of functional evaluation of insulation systems, and it appears that some of the difficulties in specifying the temperature requirements are being solved. The proposed guide for the maintenance of insulating oils which was presented at the 1956 Winter General Meeting as *CP56-358* has been submitted to the Standards Committee with the recommendation that it be published for a one-year trial period. Simultaneously, a questionnaire has been sent out to users to collect information on industry oil maintenance practices. The next project of the Insulating Fluids Subcommittee is a similar guide for the maintenance of askarels. The proposed guide for operation and maintenance of dry-type transformers with Class *B* insulation has been through a final revision, and is being submitted to the Standards Committee with the recommendation that it be made an ASA Guide. The active West Coast Subcommittee is functioning effectively in reviewing the projects in the other Subcommittees and in the Main Committee, and in suggesting new activities for the functional Subcommittees.

Science and Electronics Division

Committee on Electrical Techniques in Medicine and Biology (T. H. Rogers, *Chairman;* H. P. Schwan, *Vice-Chairman;* W. S. Lusby, *Secretary*). At the business meeting of the Committee held on January 31, a decision was made to set up a Subcommittee on Air Pollution, in view of the rapidly increasing importance of this subject. Many aspects of this problem appear to be of fundamental interest to the electrical engineering world, and it was felt that this committee would be a logical medium for the Institute's activity therein. J. C. Beckett has been designated as chairman of the Subcommittee, and its personnel and scope of activity are in the process of being established. The Committee has taken note of the establishment of a "Center for Medical Electronics" at the Rockefeller Institute. Steps to establish collaboration with the activities thereof have been taken. Collaboration with the Institute of Radio Engineers (IRE) Professional Group on Medical Electronics will also be promoted. A Subcommittee for this purpose, headed by Dr. H. P. Schwan, has been appointed. Plans for the Annual Conference on Electrical Techniques in Medicine and Biology, sponsored by this Committee jointly with IRE and Instrument Society of America, have been started. Dr. E. D. Trout, past chairman and present member of this Committee, has been designated as Conference chairman, and plans for the organization for the Conference have been initiated. The time and place have been tentatively set for the first or second week of November, in New York City. Proposals for papers for the Conference are requested to be in by June 1, so that the Program Committee can finalize the program early enough to permit adequate publicity in advance of the Conference date.

Committee on Instruments and Measurements (Ernst Weber, *Chairman;* C. F. Savage, Jr., *Vice-Chairman (East);* W. S. Pritchett, *Vice-Chairman (West);* P. K. McElroy, *Secretary*). The Committee on Instruments and Measurements met October 25 at the National Bureau of Standards, Washington, D. C., and combined a regular business meeting with a visit to the Standards Laboratories, as well as several laboratories engaged in precision measurements. The Committee prepared a petition requesting elevation to the status of the "Division on Instrumentation." With the endorsement of the Science and Electronics Division Committee and the Committee on Technical Operations, the petition was submitted to the Board of Directors and has been acted upon favorably

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Correction: On page 469 of the May issue of *Electrical Engineering*, the names of the officers of the Committee on Chemical Industry should have been: F. S. Glaza, *Chairman;* R. M. Wainwright, *Vice-Chairman;* C. R. Olson, *Secretary*.

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry,* and *Power Apparatus and Systems,* contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

at its April 3 meeting in Dallas, Tex. Group Subcommittees have again organized certain special technical conferences as follows: Recorders and Controllers Conference which was held April 26–27, in Boston, Mass., with the cosponsorship of American Society of Mechanical Engineers and the Instrument Society of America; the National Telemetering Conference scheduled for August 20–21 in Los Angeles, Calif.; and a symposium on "Scintillation Counters" held May 1–3 in Washington, D. C. Two new standards have been prepared, "Test Guide for Making Dielectric Measurements in the Field," which has been approved for a one year trial, and "Master Test Code for Rotary Speed Measurements," which has been circulated to the Committee for final approval

Committee on Magnetic Amplifiers (W. J. Dornhoefer, *Chairman;* H. W. Lord *Vice-Chairman;* A. B. Haines, *Secretary*). The Committee on Magnetic Amplifiers cosponsored the first Special Technical Conference and Exhibit on Magnetic Amplifiers held in Syracuse, N. Y., April 5–6. Other sponsors were the Institute of Radio Engineers and the Instrument Society of America. More than 540 persons registered for this conference. Since this was the first technical conference on this subject, the Conference Committee had to make many decisions based entirely upon judgment rather than upon experience. An audience "opinion poll," taken the second day, indicated that the programs and arrangements in general for this meeting were approved by the majority. It also provided guidance for future conference committees. Plans for the next Special Technical Conference and Exhibit on Magnetic Amplifiers were discussed at a luncheon meeting of the Committee on Magnetic Amplifiers held on April 6. The Steering Committee for this Conference, which will be held in 1957, has been appointed.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

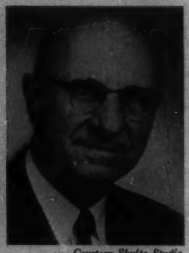
AIEE FELLOWS ELECTED

Board of Directors Meeting, April 3, 1956

Joe Emerson Barfield (M '42), vice-president, St. Joseph Light and Power Company, St. Joseph, Mo., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of an electrical utility system." Mr. Barfield was born in Gonzales County, Tex., August 13, 1895. After graduating from the University of Texas in 1917 with a bachelor of science degree in electrical engineer, he entered the Doherty Utility Training School, Denver, Colo. During World War I, he served as an instructor on aeroplane engines in the School of Military Acronautics. In 1919, he was employed by the St. Joseph Light and Power Company as a distribution engineer. In 1924, he was made superintendent of distribution and transmission. In this capacity, he was directly responsible for the design and construction of all distribution circuits, substations, and transmission circuits, in addition to the responsibility for rates, rural service, and power sales. From 1936 to 1946, he served as assistant superintendent of the company, being promoted in 1946 to superintendent in charge of distribution, transmission, steam heat, and electrical generation. In 1949, Mr. Barfield was elected vice-president in charge of operations, the position he holds at the present time. In addition to over-all responsibility for electrical and steam heat operations, he is responsible for the distribution and sale of a natural gas system at Maryville, Mo. He has been directly responsible for the system design and installation of automatic extraction turbine generating equipment for complete electric and process steam service to Swift and Company, and Armour and Company at St. Joseph, Mo. Mr. Barfield is a registered professional engineer in the State of Missouri.

John Bruce Coleman (AM '25, M '49), administrative engineer, product engineering, Radio Corporation of America (RCA), Camden, N. J., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of radio transmitters and standards in the radio engineering field." Mr. Coleman was born August 29, 1899, in Indiana County, Pa. He received a bachelor of science degree in electrical engineering in 1923 from the Carnegie Institute of Technology. He then joined the Westinghouse Electric and Manufacturing Company. In 1924, as chief engineer, Station WBZ, Springfield and Boston, Mass., he developed one of the first crystal-controlled broadcast transmitters. He then served as radio engineer on transmitter development and design, and section engineer in charge of high-power transmitter development and design. In 1930, he joined the RCA Victor Division of the Radio Corporation of America. He became chief engineer, Special Apparatus Division in 1939, and assistant director of engineering in 1945. Since 1930, Mr. Coleman has been active in the Radio-Electronics-Television Manufacturers Association. At present he is chairman of the Technical Products Panel and responsible for the work of nine main committees. He is a Fellow of the Institute of Radio Engineers, and a member of the American Society of Naval Engineers and the Franklin Institute. Mr. Coleman was a member of the U. S. Delegation at meetings of Comité Consultative International Radio in Stockholm, Sweden, 1948; Geneva, Switzerland, 1951; and London, England, 1953. He has served on the following AIEE Committees: Communications (1937–49); Air Transportation (1945–48); Television Broadcasting Systems (chairman, 1949–50); Television and Aural Broadcasting Systems (1950–56, chairman 1950–52); Technical Program (1949–50); Standards (1949–50); Award of Institute Prizes (1952–53); Special Communications Applications (1953–56); and Technical Operations (1954–56).

George J. Fiedler (AM '32, M '39), principal engineer, Sverdrup and Parcel, Inc., consulting engineers, St. Louis, Mo., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to the analysis, synthesis, and design of automatic process control systems." Mr. Fiedler was born in Bushton, Kan., March 18, 1904. He



Courtesy Shultz Studio

J. E. Barfield

J. B. Coleman

G. J. Fiedler

Ivar Herlitz

J. H. Kuhlmann

Courtesy Young's Studio

Olan Richardson

S. L. Scheffer

L. C. Whitman

attended Kansas State College, receiving a bachelor of science degree in electrical engineering in 1926, and a professional electrical engineer's degree in 1934. He received a master's degree in electrical engineering from the University of Kansas in 1932. From 1928 to 1931, he was with the Radio Corporation of America (RCA), first as a radio engineer, production department, RCA, Camden, N. J.; then as the district service manager of the Atlanta, Ga., office of RCA. From 1931 to 1933, he served as graduate assistant and instructor at the University of Kansas. He then became administrative assistant to the dean of New York State College for Teachers, Albany, N. Y. From 1935 to 1939, he was assistant professor, electrical engineering department, Union College, Schenectady, N. Y. In 1939, he became associate professor, electrical engineering department, Montana State College, and in 1943, he assumed the same position at the University of California at Berkeley. In 1945, he became chief, circuit design and measurements section, U. S. Navy Electronics Laboratory, San Diego, Calif. In this position, Mr. Fiedler had charge of the development, test, and installation of various new radio and electronic equipment for the U. S. Navy. In 1946, he joined Sverdrup and Parcel, Inc., where he is employed at the present time. During the past five years, Mr. Fiedler has directed the design of instrumentation and control systems valued at more than $10 million. These designs have varied in size from small plants to very large, complex test facilities having power, flow, temperature, and pressure ranges well beyond standard industrial practice. Mr. Fiedler has written technical papers for the publications of several of the national technical societies. He is a member of Eta Kappa Nu, Sigma Tau, and Phi Kappa Phi.

Ivar Herlitz (AM '21, M '53), director and chief electrical engineer in charge of transformer and switchgear design, Allmanna Svenska Elektriska Aktiebolaget (ASEA) Vasteras, Sweden, has been transferred to the grade of Fellow in the AIEE ". . .for distinguished contributions in the field of high-voltage engineering." Mr. Herlitz was born June 17, 1894, in Stockholm, Sweden. He received a degree in electrical engineering in 1917 from the Royal Technical Institute, Stockholm. In 1920, he received a master of science degree from Union College, Schenectady, N. Y. Dr. Herlitz joined ASEA in 1919, taking a leave of absence from 1920 to 1923, for studies in the United States. From 1923 to 1928, he served as assistant to the chief engineer, ASEA, Ludvika, Sweden. In 1929, he became a consulting engineer, power department, ASEA, Vasteras, Sweden, and in the same year was awarded the degree of doctor of technology from the Swedish Royal Technical Institute. In 1945, he was made assistant to the director of electrical engineering at Vasteras. In 1951, he assumed his present position as director and chief engineer in charge of transformer and switchgear design. One of his most important contributions has been the design and application of a major portion of the equipment on the 380-kv long-distance transmission system in Sweden. He is author of many pieces of technical literature in English, German, and Swedish. Dr. Herlitz is a member of the Swedish Association of Engineers and Architects, and the Swedish Royal Academy of Engineering Sciences. He has been president of the Swedish Electrical Technical Commission since 1949, and of the Swedish National Committee of the International Electrotechnical Commission since 1946. He has been vice-president of the Swedish Bureau for Testing Equipment since 1946, and of the Swedish National Committee for the National Commission on Rules for Approval of Electrical Equipment since its foundation in 1951. In 1954, he was elected honorary vice-president of the International Conference on Large Electric High-Tension Systems, and a member of its Administrative Council. He is a member of the Swedish National Committee for International Congresses and a director of the Swedish Standards Commission. Dr. Herlitz is a Knight of the Royal Order of Vasa.

John Henry Kuhlmann (AM '18, M '27, Member for Life), professor of electrical engineering, University of Minnesota, Minneapolis, Minn., has been transferred to the grade of Fellow in the AIEE ". . .for creative contributions to the teaching of electrical apparatus design." Mr. Kuhlmann was born in Waverly, Iowa, November 26, 1893. He received a bachelor of science degree in electrical engineering in 1917, and an electrical engineer's degree in 1921, from the State University of Iowa. From 1917 to 1920, he was a design engineer for the Electric Machinery Manufacturing Company, Minneapolis, Minn. In 1920, he joined the department of electrical engineering, Institute of Technology, University of Minnesota, as an instructor. He became assistant professor in 1924, associate professor in 1930, and professor in 1945. Prof. Kuhlmann modernized and developed the courses in design of electrical machinery, keeping in step with the ever increasing demands of power generation and consumption over the last 35 years. He wrote four manuals for class use, and as a result of the success of these manuals, he prepared and wrote a textbook, "Design of Electrical Apparatus," which was published by John Wiley and Sons in 1930. In 1950, on invitation, and with the approval of the U. S. Department of State, he was visiting professor at the University of Sao Paulo, Sao Paulo, Brazil. He spent one year introducing and establishing courses there in design of electrical machinery which were not previously offered. As a result of his success at this University, he was invited to perform a similar service for the University of Brazil, Rio de Janeiro. In addition to his responsibilities in teaching, Prof. Kuhlmann has served industry in consulting work, together with actual design responsibilities. He is a member of the Minnesota Association of Professional Engineers, the National Society of Professional Engineers, and the American Society for Engineering Education. He is also a life member of the Minneapolis Engineers Club. He served on the AIEE Committee on Student Branches (1947-50).

Olan Richardson (M '42), president, Southern States Equipment Corporation, Hampton, Ga., has been transferred to the grade of Fellow in the AIEE ". . .for contributions to protection and communication for electric power systems." Mr. Richardson was born February 2, 1904, in Gainesville, Ga. After graduating from the U. S. Navy Radio School in 1922, he served as a radioman in the U. S. Navy. He began his professional career in 1925, when he was employed by the Georgia Power Company as assistant communications engineer. In 1932, he was promoted to communications engineer, assuming full responsibility for maintaining the state-wide communications system of an expanding operating company. In 1936, he was transferred to the operating engineering department of the Georgia Power Company which, at that time, needed a better system of controlling the power flow on its 110-kv tie lines. He led in the development of a variable frequency carrier system for telemetering a continuous

recording of the tie-line load. He was active in the design, construction, and installation of completely automatic tie-line load control equipment of original design. In 1939, Mr. Richardson joined the Southern States Equipment Corporation as chief engineer. He was in responsible charge of all engineering which covered design and development of power fuses, power switching, and other substation devices. In 1940, he was elected vice-president and general manager. From 1940 to 1946, he also served as president of the Henderson Foundry and Machine Company which became the parent company of Southern States Equipment Corporation. In 1946, he was elected president of the combined companies which retained the name of the Southern States Equipment Corporation. In the power switching equipment field, under Mr. Richardson's direction, all of the air break switches manufactured by the company were converted from the area contact type to the modern high pressure contacts. In addition, he promoted the development of the "reverse loop" contact in which the magnetic force of a high current surge is used to increase the contact pressure of the switch. In the field of distribution cutouts and power fuses, he promoted a study of the behavior of fuses resulting in improved fuse design.

Lawrence Carlton Whitman (AM '39, M '45), development engineer, General Electric Company (GE), Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . .for his contributions to the improved design of dry-type insulating structures and to a better knowledge of their thermal aging." Mr. Whitman was born in Franklin, Vt., October 31, 1903. He attended the University of Vermont, receiving a bachelor of science degree in electrical engineering in 1927, and a master of science degree in physics in 1933. From 1928 to 1932, he was an engineer in the High Voltage Bushing Engineering Division of GE at Pittsfield. He then spent a year at the University of Vermont as a research Fellow and physics instructor. He returned to GE in 1936 as an engineer in the High-Voltage Engineering Laboratory. He then became an engineer in the Distribution Transformer Engineering Division. In 1937, he was made assistant to the section engineer, network transformers. In this position, he was responsible for the development and design of a complete line of dry-type transformers rated 100 to 2,000 kva, both ventilated and sealed, utilizing class B (150 C) and class H (180 C) insulations. This new major development involved many phases of electrical and thermal investigations, since little precedent was available either in the company or in the industry. Several technical papers and patents were based on work done in this assignment. He became an engineer in the distribution transformer general development section when it was formed in 1950, continuing his work on high-temperature dry-type insulating materials. He contributed substantially to the knowledge of the aging characteristics of dry-type insulations, and has had several papers published on this subject. Since 1953, Mr. Whitman has been development engineer in the distribution transformer advance product engineering subsection of GE. He is a member of Phi Beta Kappa, and the National Research Council of the National Academy of Sciences. He is registered professional engineer in Massachusetts.

Sebastian Louis Scheffer (AM '37, M '45), project director, Burns and Roe, Inc., New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . .for his contributions to control of transportation of bulk materials by rail and belt." Mr. Scheffer was born in New York, N. Y., September 23, 1907. He received a bachelor of science degree in electrical engineering from the University of Maine in 1931. From 1931 to 1934, he was employed by Gibbs and Hill, consulting engineers, New York, N. Y., working as a draftsman on electrification projects for the Pennsylvania Railroad. In 1935, he became an engineering assistant for the Phoenix Engineering Corporation (an Ebasco subsidiary), and in 1938, an assistant electrical engineer for Ebasco Services, Inc., New York, N. Y. From 1942 to 1949, he served as a relay and protection engineer, Long Island Lighting Company, Mineola, N. Y. In 1949, he joined Burns and Roe, Inc., where his work consisted of the plans, cost estimates, specifications, and designs for steam, hydro-diesel, and gas turbine driven electric power plants; for high-voltage transmission lines; and for high-voltage substations. From 1950 to 1955, he was with the Orinoco Mining Company, New York, N. Y., as an electrical engineer and project engineer where he was in charge of all electrical planning and engineering work on the project of the design, construction, and placing in operation within two years, of all necessary facilities required for mining, handling, and shiploading 10 million tons of iron ore annually from U. S. Steel's Cerro Bolivar concession in eastern Venezuela. In 1955, he assumed his present position as project director, Burns and Roe, Inc. Mr. Scheffer is a registered professional engineer in the State of New York.

Board of Directors Meeting, February 2, 1956

Joseph Edward Gahagan (AM '32, M '43), chief engineer, Ansco, a division of General Aniline and Film Corporation, Binghamton, N. Y., has been transferred to the grade of Fellow in the AIEE ". . .for his contributions to the application of industrial electronics in the field of photographic manufacturing." Mr. Gahagan was born in Silver Lake Township, Pa., January 22, 1909. He graduated from the Rensselaer Polytechnic Institute in 1930 with a degree in electrical engineering. He subsequently completed additional training in engineering, business administration, and management. From 1930 to 1942, he was with the Consolidated Edison Company of New York. In 1943, he joined Ansco, serving successively as electrical design engineer, chief electrical engineer, manager of energies and electrical engineering, plant engineer, and assistant chief engineer. In his present capacity as chief engineer, he is in charge of the general engineering department which is responsible for providing, improving, and maintaining plant facilities, and furnishing energies services. One major engineering department activity consists of the development, design, and construction of special purpose production machinery and electric and electro-pneumatic controls. Mr. Gahagan's experience at Ansco has included supervision of the design, construction, operation, and maintenance of electrical generating and distribution facilities; the design, selection, installation, and servicing of electronic controlled drives for industrial process equipment; and an electronics development laboratory engaged in the development of special controls, instrumentation, and inspection devices used in film and paper manufacture. Mr. Gahagan is a member of Sigma Xi, the New York State Society of Professional Engineers, and is a member and a past president of the Technical and Engineering Council of Southern Tier New York Area. He is a winner of the AIEE prize paper contest, Power Group, New York, 1942. Mr. Gahagan has served on the AIEE Committees on Industrial Power Systems (1950–54), and Industrial Control (1948-56).

J. E. Gahagan

AIEE PERSONALITIES

R. D. Bennett (F '35), manager of the Knolls Atomic Power Laboratory's technical department, Schenectady, N. Y., has been named manager of the General Electric (GE) Vallecitos Atomic Laboratory, which GE will have in operation in 1957 at Pleasanton, Calif. Dr. Bennett will be responsible for the company's development work at the laboratory, which will be operated in support of GE's peacetime commercial atomic activities. He received his bachelor of science and master of science degrees in electrical engineering from Union College in 1921 and 1923. He was awarded a doctor of philosophy degree in physics by the University of Chicago in 1925, and an honorary

degree of doctor of science by Union College in 1945. He was professor of electrical measurements at the Massachusetts Institute of Technology for several years, leaving in 1940 to enter the naval service. From 1944 to 1954, he was technical director of the Naval Ordnance Laboratory. He then served as manager of the technical department of the Knolls Laboratory, operated by GE for the Atomic Energy Commission. Dr. Bennett is a Fellow of the Institute of Radio Engineers and the American Physical Society; and a charter member of the American Nuclear Society. He has served on the following AIEE committees: Standards (1938–46); Marine Transportation (1943–44); Research (1947–51, 1954–55); Management (1948–53); and Education (1949–53).

R. J. Rhinehart (AM '49, M '50), division superintendent, Arkansas Power and Light Company, Pine Bluff, Ark., has been elected president of the National Society of Professional Engineers (NSPE). A Purdue University graduate in electrical engineering, Mr. Rhinehart is in charge of engineering construction, operation, and maintenance in 52 towns and cities for his company. He has been a member of the Arkansas State Registration Board for Professional Engineers for seven years, and has been president of the Board for the past three years. He is active in both professional society and civic work, and was selected as "Our Leading Citizen" by the residents of Pine Bluff in 1939. Mr. Rhinehart was formally introduced as new president of the 36,000-member NSPE at the group's annual banquet in Atlantic City, N. J., May 26. He will officially take over his duties as president on July 1. Mr. Rhinehart served on the AIEE Committee on Registration of Engineers (1953–54).

H. E. Jensen (M '41), vice-president in charge of engineering at C and D Batteries, Inc., Conshohocken, Pa., has been appointed vice-president in charge of both engineering and marketing. Mr. Jensen is a graduate of Drexel Institute of Technology, Philadelphia, Pa. Before joining C and D Batteries, he was in charge of Philco Corporation's research and development laboratory for a number of years, and served as a development engineer on classified projects for the Navy during World War II. In 1946, he took part in the atom bomb test at Bikini Atoll. In 1950, after acting as an engineering consultant for C and D for three years, he joined the firm as a development engineer. In 1951, he became chief engineer, and was named to the post of vice-president in charge of engineering in 1953.

OBITUARIES

William Henry Harrison (AM '20, M '30, F '31), president of International Telephone and Telegraph Corporation, New York, N. Y., and past president of the AIEE (1937–38), died recently at his home in Garden City, N. Y. He was 63 years old. Born in Brooklyn, N. Y., in 1892, Mr. Harrison began his career in communications with the New York Telephone Company in 1909. In 1914, he joined the Western Electric Company, where he served as engineer. During these years he attended Pratt Institute, Brooklyn, N. Y., studying electrical engineering, and graduated in 1915. From 1918 to 1933, he

Courtesy Conway Studios

W. H. Harrison

served as engineer and in administrative engineering posts with the American Telephone and Telegraph Company (AT&T) department of operations and engineering. In 1933, he was elected vice-president in charge of operations of the Bell Telephone Company of Pennsylvania, and the Diamond State Telephone Company. He returned to the AT&T department of operations and engineering as assistant vice-president in 1937, and was elected vice-president in 1938. Mr. Harrison was chosen in July 1940 to head the Construction Division of the National Defense Advisory Commission. In 1941, he became Director of Production, Office of Production Management. He also served as a member of the Joint Defense Production Committee (United States and Canada). In June 1942, he was commissioned a Colonel in the U.S. Army and, later, was promoted to Brigadier General. Elevated to the rank of Major General in July 1943, he took over direction of the Signal Corps Procurement and Distribution Service. Upon returning to civilian life, Mr. Harrison was again elected vice-president of AT&T in charge of operations and engineering, and in September 1948, he joined the International Telephone and Telegraph Corporation. In recognition of his wartime services, he was awarded the Distinguished Service Medal, War Department; the Most Excellent Order of the British Empire, degree of Honorary Commander; and the Cross of the French Legion of Honor, rank of Officer. In 1945, he was awarded the Hoover Medal. Mr. Harrison was a member of the board of directors of the Brooklyn Polytechnic Institute; board of trustees of Pratt Institute; United Engineering Trustees, Inc.; Advisory Council for Science and Engineering, Notre Dame University; Advisory Council, Department of Electrical Engineering, Princeton University; and honorary scientific societies, Eta Kappa Nu and Tau Beta Pi. Honorary degrees were given him by Brooklyn Polytechnic Institute, Notre Dame University, Rensselaer Polytechnic Institute, and Manhatten College. He served on the following AIEE committees: Technical Program (1929–36, chairman 1931–33); Co-ordination of Institute Activities (1931–33); Publication (1931–33); Award of Institute Prizes (1931–34, chairman 1931–33); Legislation Affecting the Engineering Profession (1932–37); Alfred Noble Prize (1932–34); Communication (1935–36); Edison Medal (1935–43); Lamme Medal (1935–38); Executive (1936–40, chairman 1937–38); Institute Policy (1938–40); American Engineering Council (1937–40); John Fritz Medal Board of Award (1937–41); Special Committee to Consider Associate Dues and Related Matters (1932–37); Co-operation with War Agencies (1942–45); and others.

Fred Orville McMillan (AM '14, M '26, F '32, Member for Life), head, department of electrical engineering, Oregon State College, Corvallis, Ore., and past president of the AIEE (1951–52), died recently. Mr. McMillan was born May 12, 1890, in Albia, Iowa. He received a bachelor of science degree in electrical engineering from Oregon State College in 1912, and a master's in electrical engineering from Union College in 1919. He entered the

F. O. McMillan

testing department, General Electric Company, Schenectady, N. Y., in 1912, and transferred to the engineering department in 1914. In 1920, he was appointed to the electrical engineering faculty at Oregon State College as assistant professor. He became associate professor in 1923, research professor in 1930, and professor and head of the electrical engineering department in 1937. In addition to his academic work, Mr. McMillan acted as consulting engineer for a number of public utilities; the Port of Portland, Ore., in 1925, and the United States Bureau of Fisheries from 1929 to 1933. He was appointed electrical engineering specialist to assist the Chinese Government with problems in China during 1943 and 1944. Much of his research has been in the field of high-voltage phenomena and has been reported in AIEE papers and other publications. He was a member of the American Association for the Advancement of Science, American Society for Engineering Education, Institute of Radio Engineers, Northwest Electric Light and Power Association, and the Professional Engineers of Oregon. He was also a member of Tau Beta Pi, Sigma Xi, Eta Kappa Nu, and Phi Kappa Phi. Mr. McMillan served on the following AIEE committees; Student Branches (1930–36, 1948–51, chairman 1949–51); Electrophysics (1934–37); Research (1934–36, 1938–41); Transfers (1936–42, chairman 1939–41); Education (1939–40); Technical Program (1948–50); Award

of Institute Prizes (1949–50); Publication (1949–51); Professional Group Co-ordinating, and Professional Division Committee (1949–51); Edison Medal (1950–54); Executive (1951–54, chairman, 1951–52); John Fritz Medal Board of Award (1952–56); Planning and Co-ordination (1952–54, chairman, 1953–54); and Engineers Joint Council (1952–56). He served as vice-president (1934–36), and director (1948–54).

Ernest Mercier (M '20), honorary president of the Conference International des Grands Reseaux Electriques (CIGRE), who died in Paris, France, July 11, 1955, has been honored by the Board of Directors of AIEE at its April 3, 1956 meeting, as follows: "Resolved, that the Board of Directors of the AIEE records its sense of loss and grief on the death of its esteemed, long-time Member, Ernest Mercier, Honorary President of CIGRE, and distinguished international leader in the development and use of electrical energy; and extends, on behalf of the Institute, sincere sympathy to Mrs. Mercier and Maurice Ernest Laborde (M '48), nephew and close associate of Col. Mercier." Mr. Mercier was born in 1878, at Constantine, Algeria. He graduated from École Polytechnique, after which he became a naval engineer. In 1912, he left the French Navy and was appointed chief engineer of the company "Le Triphasé." Following World War I, the Ministére de l'Armement entrusted him with reorganizing the generation and transmission of electrical energy in France. He began this project in 1919 by creating the Union d'Électricité, which consisted of a number of minor important societies. Because of his efforts, general interconnection of Parisian networks was completed in 1931. Mr. Mercier accepted the presidency of CIGRE in 1934, becoming honorary president in 1948, when he was obliged to leave. He served as chairman of the French Committee of the World Power Conference and vice-chairman of the International Chamber of Commerce.

Eugene Casson Crittenden (AM '19, M '22, F '44, Member for Life), retired associate director of the National Bureau of Standards, died recently in Washington, D. C. Dr. Crittenden was born in Oswayo, Pa., on December 19, 1880. He attended Cornell University, receiving the degree of bachelor of arts in 1905. He remained there as an instructor and graduate student until he went to the National Bureau of Standards in 1909 as an assistant physicist assigned to the Photometric Laboratory. He was named chief of the Bureau's Electrical Division in 1921, and in 1933, he was made assistant director of the Bureau, in charge of over-all research and testing activities. In 1946, the title was changed to associate director, and he assumed the responsibilities of this office on a full-time basis, continuing in this role until his retirement in 1950. Dr. Crittenden is best known for his achievements in the development and adoption of electrical and photometric standards. For his outstanding contributions to the work of the Bureau, Dr. Crittenden was awarded the Department of Commerce Gold Medal for Exceptional Service in 1949, the first year in which these awards were established. In 1946, he was honored with the Gold Medal of the Illuminating Engineering Society, and in the same year the Case Institute of Technology awarded him an honorary doctor of science degree. Dr. Crittenden was active in the work of the American Standards Association, the Illuminating Engineering Society, and the Optical Society of America, he served as associate editor of the *Review of Scientific Instruments* from 1934 to 1936. He also participated in the work of the American Society for Testing Materials, the American Institute of Physics, the National Research Council, the International Organization for Standardization, and the International Committee on Legal Metrology. Dr. Crittenden served on the following AIEE committees: Lighting and Illumination, and Production and Application of Light (1922–23, 1932–33); Research (1929–39, chairman 1938–39); Technical Program (1938–39) Award of Institute Prizes (1938–39); and Standards (1939–52).

Harry Ellis Hershey (AM '11, M '21, Member for Life), attorney at law, died recently in Chicago, Ill. Mr. Hershey was born in Eureka Springs, Ark., in 1889. He received the degree of bachelor of science in electrical engineering from Kansas State College in 1910, and the professional degree of electrical engineer in 1922. He was also a graduate of the John Marshall Law School with the degrees of LL.B. and juris doctor. In 1910, he was employed by the Automatic Electric Company, Chicago, Ill., and he remained with this company throughout his life. During his career he worked in installation, factory inspection, engineering inspection, equipment engineering, development, methods, patents, personnel, sales, and technical publications. Mr. Hershey was author and publisher of "Automatic Telephone Practice," a book on telephony, which ran through seven editions. He was granted 58 patents covering communications and remote control inventions. Mr. Hershey was a registered professional engineer and an attorney at law. He was a Member for Life of the Western Society of Engineers. He was also a member of the American Bar Association and The Illinois Bar Association. He served on the AIEE Communication Committee (1935–36).

Vernon Barnard Bagnall (M '38, F '48), assistant director of operations of long lines in charge of engineering, long lines department, American Telephone and Telegraph Company (AT&T), New York, N. Y., died recently. Mr. Bagnall, born in Jacksonport, Wis., joined AT&T after graduating from the University of Wisconsin in 1927. During World War II, he served as an officer on the staff of the U. S. Army's Chief Signal Officer. Mr. Bagnall held the rank of Colonel, and was awarded the Bronze Star for his part in establishing communications between the United States and Europe when General Eisenhower moved his headquarters to Paris. He returned to long lines department in 1946, and later became general commercial manager. Within the next several years, Mr. Bagnall served as general plant manager and as director of personnel. In July 1951, he was appointed general manager of the western area. From 1952 to January 1956, he served as project manager of the Distant Early Warning (DEW) line, now being constructed across the Arctic Circle to warn of approaching enemy aircraft. He had the responsibility of organizing and managing the project, which the Western Electric Company undertook at the request of the Department of Defense. Mr. Bagnall was a member of Eta Kappa Nu, Pi Tau Sigma, the Institute of Radio Engineers, and the Armed Forces Communications and Electronics Association.

Harvey L. Curtis (AM '21, F '26, Member for Life), retired physicist, National Bureau of Standards, died recently. He was 81 years of age. Dr. Curtis was born on a farm near Lansing, Mich. He received the degrees of bachelor of philosophy in 1900, master of arts in 1903, and doctor of philosophy in 1910, from the University of Michigan. He served as assistant professor at Michigan State College from 1903 to 1907, the year in which he joined the National Bureau of Standards. He became chief of the Inductance Capacitance Section in 1915, and of the Interior Ballistics Section in 1946. His major achievement was in the field of absolute measurements. He was made an honorary member of Phi Beta Kappa in 1940, and he was also a member of the American Association for the Advancement of Science, the American Physical Society, and the American Society for Testing Materials. Dr. Curtis served on the AIEE Basic Sciences Committee (1942–47). and was Liaison Representative of the American Physical Society (1933–42).

John Andrew Northcott, Jr. (M '40), retired head of the department of electrical engineering, University of Notre Dame, Ind., died recently at his home in Williamsburg, Va. He was 58 years of age. Mr. Northcott received a bachelor of engineering degree from North Carolina State College in 1918. He then was employed by the Westinghouse Electric Corporation. In 1922, he joined the faculty of Notre Dame, serving as department head from 1938 to 1954. Prof. Northcott was counselor of the Notre Dame Branch of AIEE for a number of years, and also past chairman of the South Bend Section. He served on the AIEE Education Committee (1942–50).

Sterling Marshall Gardner (AM '18, M '26, Member for Life), founder of the Gardner Electric Manufacturing Company, a subsidiary of Federal Pacific Electric Company, in Emeryville, Calif., died recently. He was 70 years old. Born in Nebraska, Mr. Gardner moved to Oakland, Calif., as a young boy and graduated from Polytechnic School of Engineering. He was awarded one of the world's first amateur radio licenses with the call letters *W6JCR*. During World War II, he was a member of the nation-wide "ham" network. Establishing the transformer plant in Oakland in 1909, Mr. Gardner soon engaged in considerable diversification and extended operations to include manufacture of neon sign transformers. Gardner Electric designed and developed the first neon sign transformer approved by Underwriters' Laboratories in 1926. Another "first" was the winding of the coils of the first cyclotron. In 1954, Gardner Electric Manufacturing Company was pur-

chased by Federal Pacific Electric Company of Newark, N. J. Mr. Gardner was a member of the Oakland Radio Club, and the Allied Scientists of the World.

John Martin Mellor (AM '49), retired New England district manager for the Ohio Brass Company (O-B), Mansfield, Ohio, died recently at Danielson, Conn. Mr. Mellor was born in Cambridge, Mass., November 21, 1888. From 1913 to 1915, he was a master mechanic for the Connecticut Company, and from 1915 to 1920, he served as vice-president and general manager of the Hartford and Springfield Street Railway Company. He joined O-B in 1920 as a car equipment specialist for the New England territory, and became a district manager eight years later, serving both railway and power utility customers in the area. He retired January 1, 1956 after 35 years of service with the company. Mr. Mellor was a member of the New England Railroad Club.

Christian A. Reiser (AM '47), special tester, Philadelphia Electric Company, Philadelphia, Pa., died recently. He was born in Zurich, Switzerland, June 15, 1897. He graduated from State College, Zurich, in 1920 with a degree in electrical engineering. He also attended the University of Pennsylvania after he came to the United States. From 1920 to 1924, Mr. Reiser was an electrical engineer in a factory for electrical measuring and scientific instruments, Trueb, Tauber and Company, Zurich. In 1925, he was employed in the testing section, engineering department, standardization branch of the Philadelphia Electric Company. There he tested and calibrated such instruments as are used in a large utility company.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of April 19, 1956, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Alexander, F. M., project engineer, Industrial Nucleonics Corp., Columbus, Ohio.
Anderson, L. F., engineering manager, photolamp div., Sylvania Electric Products Inc., Montoursville, Pa.
Barry, L. C., design engineer-distribution, Southwestern Gas & Electric Co., Shreveport, La.
Barter, L. D., district C & A engineer, Westinghouse Electric Corp., San Francisco, Calif.
Bayerd, F. G., engineering representative, Kearfott Co., Inc., Seattle, Wash.
Boulton, V. R., assistant principal engineer, test div., Aerojet General Corp., Sacramento, Calif.
Brett, E. D., supervising electrical engineer, Bouillon & Griffith, Seattle, Wash.
Buck, A. F., industrial sales dept. manager, Westinghouse Electric Corp., St. Louis, Mo.
Campbell, C. E., partner, Emery, Marker & Campbell, Toledo, Ohio.
Chandler, W. M., Jr., electrical engineer, Larson & Silver, Norfolk, Va.
Chatterjee, R. (Mrs.), lecturer, Indian Institute of Science, Bangiore, India.
Chellapa, T. R., engineer, Sankey Electrical Stampings, Ltd., Bombay, India.
Claggett, T. J. C., assistant engineer, electric test dept., Baltimore Gas & Electric Co., Baltimore, Md.
Cole, W. H., assistant distribution supervisor, Florida Power & Light Co., Coral Gables, Fla.
Cox, H. N., systems application engineer, General Electric Co., Schenectady, N. Y.
Crothers, J. M., supervisory electrical engineer, Catalytic Construction Co., Philadelphia, Pa.
Crumb, S. F., project aerophysics engineer, CONVAIR, Fort Worth, Tex.
Davis, M. N., industrial & commercial engineering supervisor, Sacramento Utility District, Sacramento, Calif.
Dodson, T. A., head electrical engineer, Lower Colorado River Authority, Austin, Tex.
Douville, F. W., staff engineer, Kaiser Aluminum & Chemical Corp., Spokane, Wash.
Early, H. C., research engineer, University of Michigan, Ann Arbor, Mich.
Emerson, H. J., electronic development engineer, Eastman Kodak Co., Rochester, N. Y.
Festner, R. H., supervising engineer, New York Telephone Co., New York, N. Y.
Fisher, L. L., project engineer, Lenkurt Electric Co., San Carlos, Calif.
Fladd, A. J. J., engineer, Roushey & Smith, Wilkes-Barre, Pa.
Gezon, L. B., manager-marketing, low voltage switchgear dept., General Electric Co., Philadelphia, Pa.
Gilbert, R. G., design engineer, delta-star electric div., H. Inc. Porter Co., Inc., Chicago, Ill.
Gillentine, W. A., district engineer, Southern Bell Tel. & Tel. Co., New Orleans, La.
Gold, S. H., protection engineer, California Electric Power Co., Riverside, Calif.
Goodman, W. E., application engineer, Line Material Co., Memphis Tenn.
Green, M. E., chief engineer, North-West Telephone Co., Vancouver, Can.
Haig, A. L., electrical engineer, light dept., City of Tacoma, Tacoma, Wash.
Hauspurg, A., staff engineer, American Gas & Electric Service Corp., New York, N. Y.
Hawkins, T., switchgear engineer, Federal Pacific Electric Co., St. Louis, Mo.
Hazan, E., electrical engineer, Sacramento Municipal Utility District, Sacramento, Calif.
Henry, S. D., division operating superintendent, Metropolitan Edison Co., Easton, Pa.
Hertz, H. F., junior engineer, Philadelphia Electric Co., Philadelphia, Pa.
Hicks, J. D., general superintendent of operations, Tampa Electric Co., Tampa, Fla.
Hills, J. F., design engineer, B. C. Engineering Cp., Ltd., Vancouver, B. C., Can.
Horton, E. G., Connecticut valley district manager, Westinghouse Electric Corp., Hartford, Conn.
Huffstutter, J. W., design engineer, Westinghouse Electric Corp., Sharon, Pa.
Ilinski, V. I., designer, Bechtel Corp., Vernon, Calif.
Jancar, J. A., consulting & application engineer, Westinghouse Electric Corp., Detroit, Mich.
Jorgensen, G. D., supervising engineer, R. W. Beck & Associates, Seattle, Wash.
Kenny, G. L., Jr., transmission & distribution superintendent, Florida Power Corp., St. Petersburg, Fla.
Koon, K. S., development engineer, International Business Machines Corp., Endicott, N. Y.
Kral, A., assistant section engineer, product div., M. W. Kellogg Co., New York, N. Y.
Langton, K. R. N., assistant development design engineer, Hydro Electric Power Commission of Ontario, Toronto, Ont., Can.
Lantz, F. V., electrical engineer, Gilbert Associates, Inc., Reading, Pa.
Leas, H. W., project engineer, Metropolitan Edison Co., Easton, Pa.
Lees, J. R., field application engineer, I-T-E Circuit Breaker Co., Clayton, Mo.
Licini, F. R., project engineer, Pennsylvania Power & Light Co., Allentown, Pa.
Lindsay, E. W., design engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Lindskog, S. W., electrical service supervisor, Westinghouse Electric Corp., Boston, Mass.
Lindsley, F. M., communications supervisor, Western Electric Co., New York, N. Y.
Lotz, C. A., electrical engineer, Metropolitan Edison Co., Reading, Pa.
Malik, M. A., projects engineer, PWD, Government of Punjab, Lahore, West Pakistan.
McCroskey, W. N., advance engg. manager, General Electric Co., Fort Wayne, Ind.
McGuiness, C. A., electrical superintendent, Alleghany Industrial Electrical Co., Inc., Atlanta, Ga.
Mesmeringer, J. C., Jr., senior engineer, The Glenn L. Martin Co., Baltimore, Md.
Moore, J., manager, distribution apparatus sales, Westinghouse Electric Corp., St. Louis, Mo.
Mower, L. D., electrical engineer, Chas. T. Main, Inc., Boston, Mass.
Muhlenich, R. R., design engineer, Westinghouse Electric Corp., Sharon, Pa.
Mussina, G. A., technical assistant to chief engineer, Baltimore Gas & Electric Co., Baltimore, Md.
Nesbitt, W. B., distribution engineer, Public Service Co. of Oklahoma, Tulsa, Okla.
Newcomb, A. J., Jr., superintendent, Richardson-Wayland Electric Corp., Roanoke, Va.
Nichols, L. L., Jr., assistant professor of electrical engineering, Virginia Military Institute, Lexington, Va.
Nonemaker, L. L., staff assistant, Pennsylvania Power & Light Co., Allentown, Pa.
Noyes, L. D., production supervisor, General Electric Co., West Lynn, Mass.
Ortmann, H. Jr., manager, engineering section, Westinghouse Electric Corp., Newark, N. J.
Pellinen, A. E., electrical engineer, U. S. Bureau of Reclamation, Sacramento, Calif.
Petrich, R. O., application engineer, Garland Affolter Engineering Corp., Seattle, Wash.
Plonsky, A. W., professor, University of Scranton, Scranton, Pa.
Powers, S. H., electrical engineer, W. R. MacCumber Inc., Glenbrook, Conn.
Rathaman, B. G., vice president, A. B. Karlstads Mek. Werkstad, Werkstad, Sweden
Reime, P. W., senior electrical engineer, Sverdrup & Parcel, Inc., St. Louis, Mo.
Robertson, T. M., engineer, Vitro Laboratories, Silver Spring, Md.
Roby, J. G., application engineer, General Electric Co., Baltimore, Md.
Rockwell, R. L., senior distribution engineer, Alabama Power Co., Mobile, Ala.
Rose, R. B., district manager, General Electric Co., St. Louis, Mo.
Rutecki, J. E., electrical service supervisor, Westinghouse Electric Corp., Boston, Mass.
Schatz, E. J., electrical engineer, Gilbert Associates, Inc., Reading, Pa.
Scheufele, G. C., project engineer, Black & Veatch, Kansas City, Mo.
Seale, A. C., Jr., substation maintenance supervisor, Long Island Lighting Co., Hicksville, N. Y.
Shettle, W. A., electrical engineer, J. G. White Engineering Corp., New York, N. Y.
Slothower, J. C., transmission operating engineer, Northern States Power Co., Minneapolis, Minn.
Smitherman, R. S., district engineer, Southwestern Gas & Electric Co., Mt. Pleasant, Tex.
Southgate, R. N., assistant to electrical engineer, Public Service Electric & Gas Co., Newark, N. J.
Standish, T. A., manager, rate & research dept. Houston Lighting & Power Co., Houston, Tex.
Strelinger, J. C., electrical designer, Ramsyer & Miller, Inc., New York, N. Y.
Temme, H. C., electrical engineer, Black & Veatch, Kansas City, Mo.
Terhaar, E. J., electrical engineer, U. S. Bureau of Reclamation, Sacramento, Calif.
Timascheff, A. S., senior electrical engineer, Aluminum Co. of Canada, Montreal, Que., Can.
Walkley, W. W., application engineer, General Electric Co., Schenectady, N. Y.
Watt, G. J., section head, gyro instrument div., Sperry Gyroscope Co., Garden City, N. Y.
Webster, J. A., assistant chief engineer, Sandwell & Co., Ltd., Vancouver, B. C., Can.
Weddendorf, W. A., electrical engineer, Mutual Boiler & Machinery Insurance Co., Waltham, Mass.
Wenger, J. S., transmission engineer, The Detroit Edison Co., Detroit, Mich.
Wey, R. C., electrical engineer, senior, Ohio Power Co., Canton, Ohio.
Williams, G. H., electrical engineer, Radio Corp. of America, Camden, N. J.
Wright, H. R., chief engineer, Alaska Pine & Cellulose, Ltd., Vancouver, B. C., Can.
Wulfken, A. J., design engineer, Corbett & Tinghir Co. Inc., New York, N. Y.
Yang, T., senior engineer, Eckert-Macuhly div., Remington Rand, Philadelphia, Pa.

103 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before June 25, 1956, or July 25, 1956, if the applicant resides outside of the United States, Canada or Mexico.

To Grade of Member

Agnew, E. J., Westinghouse Air Brake Co., Pittsburgh, Pa.
Bosseri, A. J., Cornell Aeronautical Lab., Inc., Buffalo, N. Y.
Brooks, R. E., Western Electric Co. Inc., Winston-Salem, N. C.
Burns, R. L., Southwestern Bell Tel. Co., St. Louis, Mo.
Cook, C. D., Dept. of the Army, Office of Ordnance, Washington, D. C.
Dubois, E. J., Automatic Switch Co., Newton, Mass.
Gardner, G. B., Aerovox Corp., New Bedford, Mass.
Gazzana-Priaroggia, P., Pirelli S.p.A., Milan, Italy.
Hadden, G. R., Consolidated Edison Co. of N. Y., New York, N. Y.
Hall, N. I., Hughes Aircraft Co., Culver City, Calif.
Hartley, G. R., Bechtel Corp., San Francisco, Calif.
Holt, G. T., Fairbanks, Morse & Co., Beloit, Wis.
Kerley, J. J., Jr., Westinghouse Electric Corp., Baltimore, Md.
Keyes, J. H., Jr., McDonnell Aircraft Corp., St. Louis, Mo.
Kirsch, E. J., Line Material Co., Milwaukee, Wis.
Koerner, C. A. (re-election), Electrical Engineers Equipment Co., Melrose Park, Ill.
Lavender, J. R., General Electric Co., West Lynn, Mass.
Macpherson, W. R., Alaskan Air Command USAF, Seattle, Wash.
Marvin, R. A., Northern Electric Co. Ltd., Montreal, Que., Canada.
Nair, E. N., Gal Oya Development Board, Aparai, Ceylon.
Palandri, G. L., Pirelli S.p.A., Milan, Italy.
Palfreyman, C. D., Snowy Mountains Hydro-Electric Authority, Sydney, Australia.
Runyon, C. F., Olin Mathieson Chemical Corp., Niagara Falls, N. Y.
Sawitz, P. H., American Research & Mfg. Corp., Bethesda, Md.
Schimansky, B. G., Cleveland Elec. Illuminating Co., Cleveland, Ohio.
Seymour, J. W., RCA International Division of Clark, New Jersey, Rangoon, Burma.
Stephenson, G. E., Control Instrument Co. Inc., Brooklyn, N. Y.
Vennard, E., Edison Electric Institute, New York, N. Y.

28 to grade of Member

IN EDUCATIONAL CIRCLES

ACTIVITIES AND INTERESTS

1956 District 4 Student Conference Held at Clemson College

THE DISTRICT 4 STUDENT Conference and Paper Competition was held at Clemson College, Clemson, S. C., April 11–13, 1956. Students, counselors, and guests numbering 177 attended the meeting. The program included a social hour on Wednesday evening, April 11; student paper presentations on Thursday and Friday mornings, April 12 and 13; industrial plant inspection tours on the afternoons of April 12 and 13; and a banquet and business meeting on the evening of April 13.

Chairman of the Judging Committee, Prof. J. C. McKee, Mississippi State College, presided at the two paper sessions. Winner of the first prize was C. O. Alford, Georgia Institute of Technology, for his paper, "The Magnetic Amplifier as a Low Frequency Modulator." Second prize was won by S. R. Harrell, North Carolina State College, for "Locating Transmitter Sites for Military Installations." Honorable mention was awarded to three papers: "Vibration Studies with a Photoelectric Cell," by J. A. Gioiello and B. E. Pope, University of Alabama; "An Application of Analogue Computers in Testing Servomechanisms," by J. M. Wright, University of Louisville; and "Nuclear Resonance Magnetic Fluxmeter," by J. A. Van Order and J. C. Rudisill, Jr., Duke University.

Papers were also presented by the following students: H. C. Lollar and J. F. Mizell, "Photoformer as a Function Generator," Mississippi State College; W. H. Pace, Jr., "An Electronic Analogue to the Operation of an Instructor's Mind While Deciding Grades," Tulane University; P. R. Little, "New Vacuum Pumps for Industry," University of Virginia; L. E. Frase, "Guided Missile Telemetry," Virginia Military Institute; D. A. Trainum, "Electromechanical Wave Filters," alternate paper, University of Virginia; and J. J. Westman, "An Analysis of the Double Valued Dynamic Characteristic Curve," University of Florida.

Industrial plant inspection tours were made each afternoon to the plants of Sangamo Electric Company, Pickens Division, Pickens, S. C.; Owens-Corning Fiberglas Corporation, Anderson, S. C.; and Duke Power Company Lee Steam Station, Williamston, S. C.

Bruce Cloaninger of Clemson College acted as toastmaster at the banquet. Vice-President of District 4, Prof. W. J. Miller, announced the winners of the paper competition.

After the banquet, the counselors meeting was held with H. V. Poe, District 4 chairman of student activities, presiding. Concurrently, a student meeting was held with Paul Hagen, Clemson Branch chairman, presiding.

In a combined meeting, the invitation of Mississippi State College to act as host and hold the next Student meeting in conjunction with the forthcoming District meeting in Jackson, Miss., was unanimously accepted. Prof. J. C. McKee of Mississippi State College was elected District Chairman of the Student Activities Committee for next year by acclamation.

DISTRICT 4 VICE-PRESIDENT, Prof. W. J. Miller (*left*), congratulating first place winner of Paper Competition, Cecil Alford (*center*) of Georgia Institute of Technology, while second place winner, S. R. Harrell (*right*) of North Carolina State College, looks on. In the background is Toastmaster Bruce Cloaninger of Clemson College.

AIEE-IRE Student Branch Activities at SDSMT

The AIEE student prize paper competition at the South Dakota School of Mines and Technology (SDSMT) branch was held February 21. Winners were William Reuter, "Alternator Short Circuits," first place; Delmar Schley, "A Bass Reflex Speaker Enclosure," second place; Erich Bruescke, "Characteristics of Snap Action in Magnetic Amplifiers," and John Mohr, "Detection of Polarity of Corona Discharge," honorable mention.

SDSMT has the honor of having the largest percentage of its graduating engineers listed in "Who's Who" of any engineering college in the United States. This fact was reported in "A Study of College Graduates in the 1954 Edition of Who's Who in Engineering" by C. J. Baer, University of Kansas.

The Institute of Radio Engineers (IRE) division of the branch at SDSMT was awarded the Sigma Tau scholarship trophy this year. The scholarship trophy is to be awarded annually to the group or organization on the campus of SDSMT who have the highest grade-point average. Sigma Tau is an honorary scholastic association located on the campus.

U of I Student Branch Receives Display Award

The University of Idaho's annual Associated Engineer's Ball was held February 18 in the Student Union Ballrooms of the U of I campus. All students of the College of Engineering and their friends were invited to attend.

Highlighting the Ball were displays created and exhibited by the Student Branch members of the AIEE, American Society of Civil Engineers, American Society of Mechanical Engineers, American Society of Agricultural Engineers, and American Institute of Chemical Engineers. Each exhibit was judged on originality, ingenuity, audience participation and appeal, apparent work involved, and personal opinion. Faculty advisors of each Student Branch acted as judges.

Winner of the perpetual golden plaque was the display entered by the AIEE Student Branch, their theme being "Progress

of Electricity." The winning exhibit began with a simulation of Benjamin Franklin's kite experiment, and through a series of 10 major steps of development, displayed electrical progress up to and including a working model of a transistor radio receiver built by one of the members. For the guests participation and amusement, a switchboard and dial telephone were used to activate each step individually through a combination of switches. Constructing and displaying the exhibit required 250 man-hours of labor by the AIEE student members.

G. A. Riedesel, a representative of the Society of Professional Engineers, presented the award to AIEE Chairman Russell Boor.

Cornell Engineers Win Student Paper Contest

Four students of the College of Engineering, Cornell University, Ithaca, N. Y., have been awarded prizes in an annual student paper contest sponsored by the Ithaca Section of the AIEE.

J. L. Haynes, winner of the first prize of $40, also competed in the AIEE North Eastern District student paper contest in Rochester on May 4. His paper was on "The Realization of Infinity."

L. L. Phillips, whose paper was "The Problem of the National Shortage of Engineers," won second prize of $30.

The $20 third prize winner, H. P. Janes, discussed "The Determination of Atmospheric Refraction of Radio Waves by Interferometer Techniques."

A paper on "A Digital Differential Analyzer," by I. M. Jacobs, won the fourth prize of $10.

MIT Offers "Vibration, Shock, and Noise" Program

"Vibration, Shock, and Noise" will be the subject of a two-week special summer program to be given at the Massachusetts Institute of Technology (MIT) June 18–29 during the 1956 Summer Session.

The director of the MIT Summer Session points out that modern mechanical design requires increasing attention to the problems of controlling vibration and noise, and designing to withstand shock. The two-week program, which will provide a survey of recent advances in these fields, will consist of lectures supplemented by demonstrations and visits to MIT laboratories doing work in vibration and acoustics.

Subjects to be discussed under the three main topics include—in the field of vibration: elementary theory, vibration reduction and isolation, impedance and mobility methods, and the application of high-speed digital computing machines to vibration calculations; in the field of shock: response of structures to shock, principles and practice of shock isolation, and shock testing; and in the field of noise: measurement of noise, control of noise, and jet noise and aircraft fatigue.

Guest lecturers will include: C. E. Crede, director of engineering at Barry Controls, Watertown, Mass.; Dr. Chiniro Hayashi, professor of electrical engineering at Kyoto University, Kyoto, Japan; A. C. Pietrasanta, acoustical engineer at Bolt, Beranek and Newman, Cambridge, Mass.; and Dr. Robert Plunkett, vibration engineer at the General Engineering Laboratory, General Electric Company, Schenectady, N.Y.

Registrants for the special summer program in "Vibration, Shock, and Noise" may reserve rooms in the Institute's domitories during the program. All MIT recreational facilities, including the swimming pool and the popular sailing pavilion on the Charles River Basin, are available for their use.

Full details and application blanks may be obtained from the Summer Session Office, Room 7–103, Massachusetts Institute of Technology, Cambridge, Mass.

R. E. Snowman To Compete at Summer and Pacific Meeting

R. E. Snowman, senior electrical engineering student at California State Polytechnic College, will represent Southern California in the student prize paper competition to be held at the AIEE Summer and Pacific General Meeting in San Francisco, Calif., June 25–29.

Mr. Snowman became eligible to compete by winning first place in the annual student prize paper contest recently held by the AIEE Southern California Section in Los Angeles. This is the first year the college has been represented in the competition because its AIEE student branch was chartered only recently.

The prize paper contest is open only to to colleges and universities having local AIEE student chapters.

At San Francisco, Mr. Snowman will compete with winners of other regional contests throughout the western states. The subject of his paper was, "Analysis of Symmetrical Components Using a Three-Phase Oscillograph."

WCEMA Launches Scholarship Program

The West Coast Electronic Manufacturers Association (WCEMA) has launched its 1956–57 Scholarship Fund drive, according to T. P. Walker, president of the association, which annually develops a fund to provide engineering scholarships to students in West Coast colleges and universities.

During the current school term, 25 students are attending 15 West Coast schools under sponsorship of the WCEMA Scholarship Fund. To qualify, students must indicate their intention of entering the field of electronics. The scholarships are given to freshmen and sophomores who are taking courses leading to degrees in electrical or mechanical engineering or physics. The scholarships are given to the schools, with the deans of engineering responsible for selection of deserving students.

In 1955–56, the following schools received scholarships: University of Arizona, California Institute of Technology, California State Polytechnic College, The University of British Columbia, University of California at Berkeley, University of California at Los Angeles, University of Idaho, Oregon State College, San Diego State College, San Jose State College, University of Santa Clara, University of Southern California, Stanford University, University of Utah, and University of Washington.

It is hoped that the 1956–57 Scholarship Fund, which is developed by the contributions of WCEMA members and others in the electronics industry, will allow addition of several schools to the program.

Notre Dame Paper Competition

JAMES MASSEY *(second from right)*, Ottawa, Ill., won the annual student paper competition at the University of Notre Dame sponsored by the South Bend section of the AIEE. His subject was "The Magnetic Pole." He recently won a National Science Foundation fellowship and plans to take advanced studies at the University of Illinois. Other finalists in the competition were *(left to right)* Robert Minck, Defiance, Ohio; Greg Conron, New Canaan, Conn.; and George Krembs, Merrill, Wis. L. F. Stauder, associate professor of electrical engineering and faculty moderator holds award certificate.

OF CURRENT INTEREST

COVER for Hiwassee Dam outdoor powerhouse pump-turbine unit, the world's largest, being moved by gantry crane.

A-C Industrial Press Photo

World's Largest Reversible Pump-Turbine Unit in Full Operation

THE WORLD'S LARGEST reversible pump-turbine unit is the heart of a unique plan for storing large blocks of power at the Tennessee Valley Authority's (TVA) Hiwassee Dam. This is the first installation in the Western Hemisphere of a reversible pump-turbine for the initial purpose of helping to level system load curves. The pump-turbine was designed and built by Allis-Chalmers Manufacturing Company.

Electrical Rating

Electrically, this dual-purpose machine is rated 70,000 kva as a hydraulic turbine-generator and 102,000 hp as a pump-driving motor—the world's largest by more than 20,000 hp. Hydraulically, it is designed to generate 80,000 hp under a 190-foot head—to pump 3,900 cubic feet per second against a 205-foot head. Rotation is clockwise for generating, and is counter-clockwise for pumping.

In pumped-storage systems, the reversible pump-turbine unit can generate electric power to help meet peak daytime demands, drawing on water stored for that purpose. In off-peak nighttime or week-end hours, the supply of available electric power exceeds the normal demand. The machine can then be motorized to pump water back into the storage reservoir. It is, in effect, the means by which surplus electrical energy can be converted to water power, stored and re-converted when needed to fill electric power requirements. With the large reversible pump-turbine units, approximately 3 kilowatts can be generated for every 4 kilowatts used for pumping. The Hiwassee unit will assure maximum plant capacity during seasonal peak-load periods when water level is normally low.

Records Set

The new machine boasts many record breakers. In addition to being the world's largest pump-turbine, its 266-inch Francis-type runner is larger in diameter than any other. The electrical component, rated 102,000 hp as a motor, has no equal. If full pumping capability of the unit were utilized over a 24-hour period at lower than rated head, it would lift more than 3.25 billion gallons of water—three times the average daily requirement of New York, N.Y.

Significantly, although it is a relatively new concept, components of the reversible pump-turbine are little different from those already incorporated in many vertical hydroelectric machines. The pivoted shoe-type thrust bearing, for example, is inherently suited for reversible operation. The bearing for the Hiwassee machine supports a total of 1,365,000 pounds.

To reduce breakaway torque in startup, both for motoring and generating, thrust bearings for reversible units are fitted for high-pressure lubrication. The high-pressure system operates in the starting cycle, establishing a film of oil between thrust bearing surfaces so effectively that one man can readily start the Hiwassee machine rotating by pushing against an arm of the rotor spider. This system is in use on very large hydro-generator installations, as well.

Characteristics Variations

Variations between the unit's electrical characteristics and those of a typical hydraulic turbine-generator are chiefly due to its dual purpose as generator and motor. Ratings are 102,000 hp, 95 per cent power factor, 80-C rise, 13,500 volts, 135.9 rpm as a motor; 59,500/68,425 kw, 70,000/80,500 kva, 60- to 80-C rise, 85 per cent power factor, 105.9 rpm as a generator.

A ring of 20 adjustable wicket gates controls the flow of water to the unit's impeller runner for power generation, and likewise regulates the flow of pumped water for greatest efficiency. When starting as a pump,

the wicket gates are closed and a compressed air blow-down system dewaters the runner. This reduces motor starting torque requirements and eliminates system disturbances. Reduced voltage starting limits current inrush below normal load. The motor is then started and brought up to speed. Release of air pressure allows the water level to rise in the impeller, the wicket gates slowly open to the proper setting and water flows up the penstock into the storage reservoir. Much the same sequence in reverse, is followed at the end of the pumping cycle. For power generation, the unit is started in the same manner as a conventional hydraulic-turbine unit.

Sizes of Units

The 266-inch turbine runner was built and shipped in three sections, and bolted together at the job site. The largest runner of this type that could be handled as a single shipment would be rated 48,000 hp, compared to 80,000 hp for the runner which is now installed.

The generator-motor stator was also built and shipped in three sections, partially wound at the factory, and finish-wound on the job. The rotor spider was too large in diameter to meet shipping limits and it also was shipped in sections and bolted together at the dam site. Rim laminations and field poles were assembled on the spider just prior to installation. Finished rotor weight was over 300 tons.

The concept of pumped storage for hydraulic power purposes is not new. However, the reversible unit, which combines pump and turbine, generator and motor, into a single integrated machine, is a recent development.

Another unit of this type, also built by Allis-Chalmers, is operating in the Flatiron Power and Pumping Plant in Colorado.

A-C Industrial Press Photo

OVER-ALL VIEW of Hiwassee Dam in southwestern North Carolina showing partially assembled, tarpaulin protected pump-turbine. The weather top for the gigantic unit is at the extreme left.

Induction Motors Produced in the "Most Modern Factory"

BELIEVED TO BE the world's most modern factory for making induction motors, the medium induction motor department was unveiled in Schenectady, N. Y., by General Electric (GE) recently.

The new facility was built at a cost of approximately $7 million to meet today's rapidly expanding motor market which is expected to increase at least 75 per cent, industry-wide, by 1965.

Actually three plants under one roof, the new motor plant has made possible a three 8-hour shift production cycle on standard models of the 7½- to 30-horsepower motors in the *Tri-Clad 55* (trade-mark) line. Formerly, it took two weeks to produce these motors.

Assembly Methods

Standard models are manufactured in a straight-line flow on left and right assembly lines, with special motors produced in a middle line which draws standard components from the other two.

Highlighted by many new manufacturing processes which have reduced to two the number of major hand operations involved, the facility is geared to meet upward production demands in an expanding motor market.

Despite the reduction in hand operations, the new plant employs more personnel than ever before.

Principal hand operations still in use on the two standard lines involve stator winding and a portion of final motor assembly. All other operations are performed on machines which function automatically—most in a series of progressive machining.

Factory Setup

Designed from a "building block" approach, the factory was set up specifically for manufacture of the *Tri-Clad 55* line, introduced in 1954. First production line was installed early in 1955 for the 250 frame size. By August 1955, the factory had attained quantity production of all three of its *Tri-Clad* frame sizes in 7½ to 30 hp manufactured to the new National Electrical Manufacturers Association (NEMA) specifications. The factory produces more than 100 standard models, plus a wide variety of special motors.

Motor parts progress towards final assembly and testing along roller-type conveyors, with an overhead suspension system employed as needed for the handling of materials and for such operations as moving the wound stators through an automatic dip-and-bake process.

Punch Press Stations

Feature of the standard lines is an array of punch presses stationed at the beginning of both production lines. The punching operations are fully automatic—including feed of the sheet steel into the presses, movement of the punchings from blanking to indexing presses via magnetized conveyor belts, and removal of metal waste.

Metal scrap from the punchings is collected under the floor in an automatic operation conveying it to a chute which shakes the scrap into a large bucket. The cycle is concluded as the bucket fills to a preset load, when it automatically lifts to a position where

Courtesy GE News Bureau

Courtesy GE News Bureau

MOLTEN ALUMINUM ALLOY (above), heated to more than 1,000 F, is pressure-cast into rotor core in process which prevents air pockets from forming in core. Internal fan fins are cast as one piece with rotor for extra strength. End shields are machined at multiple stations (right). New tooling and equipment helps assure better alignment of bearings for longer life.

the scrap is dumped into a collection truck outside the building. The bucket then returns again to its original position at the end of the chute. Shaking operation of the chute starts and stops at set intervals as part of the cycle.

Machining Operations

All machining operations on 250-size frames are performed at a single machine where the feet are milled, footholes and conduit box holes drilled, shaft hole bored and rough-finished, and holes bored and tapped for the endshield bolts—all in a progressive series of automatically controlled operations. Each previously was a separate operation performed at four different machines.

In another fully automatic operation, wound stators are passed through three ovens in a dip-and-bake process on a preset cycle of about six hours. They are progressively preheated, dipped into varnish, baked, given paint dip, baked again, and finally given a silicone dip. Hand operations are limited to loading and unloading.

Testings

The many testing operations demonstrate the great emphasis placed on quality control. All motors are tested automatically on a circular platform at the end of each standard line. Designed to handle six motors at a time, the platform is rotated to perform tests on a total three-minute cycle for such factors as vibration, noise, electrical resistance, and high voltage reaction.

A previous production-line test for turn-to-turn failure, unbalanced resistance, and high voltage is given at the point where the wound stators are prepared for the dip-and-bake processing. At regular intervals, fully assembled motors are selected for additional testing. Along both standard lines and the special line all operators check their own work as it progresses toward final assembly. "Floating inspectors" also check the work at various stations.

As they leave the final test platform the motors are crated and raised by an automatic lift into a giant, slotted storage bank—similar in principle to the self-filling slots in some food markets.

Storage

Accommodating more than 1,000 boxed motors at one time, the bank receives the motors at one end—placed into slots according to size and model—and by means of sloped roller conveyors lets each box move forward as the boxes ahead are removed.

The new factory, it is stated, has made possible both an improvement in quality of the finished motor, primarily through an improved uniformity in manufacture, and faster service through heightened flexibility.

On the normal production schedule, each of the more than 100 standard models is manufactured every two weeks. The high degree of flexibility in the new manufacturing layout, however, permits change of the schedule at any time to meet a particular market demand.

Permanent Magnet Use Reduces Size and Increases Compass Accuracy

NAUTICAL COMPASSES today have a new look because of a simple permanent magnet design. Besides a new look, they are less expensive and more accurate.

The Marine Compass Company, Pembroke, Mass., and E. S. Ritchie and Sons Company—102-year-old compass pioneer which built the first magnetic compass used on the first "iron" ship built during the Civil War—were responsible for this vast change.

Like most progressive companies, Marine Compass' problem was to develop a better quality product. Specifically, the problem was—how to reduce weight on the pivot and at the same time add more built-in accuracy.

Magnetic compasses in use were only one step away from the 100-year-old design which made use of a single bar magnet. An 8-inch compass, for instance, employed as many as four to eight tube-type magnets, and required the use of a large buoyancy chamber to provide "float-free" action in the compass liquid.

The magnets themselves were a number of high tungsten alloy steel wires sealed in a brass tube, then magnetized. As many as 12 fine wires were needed to manufacture each tube magnet.

To provide magnetic strength needed, it was necessary to use magnets $3^1/_2$- to 4-inches long. This, as well as the large card for readings, made it necessary to employ the use of a buoyancy chamber to reduce the amount of drag on the pivot.

Today, light-weight GE (General Electric) Alnico magnets eliminate the need for the costly buoyancy chamber and greatly improve compass performance. These magnets provide an almost uniform flux pattern to give a uniform deviation chart for each compass when compensated. The U. S. Navy which periodically compensates its own compasses on every ship, for example, spends hours at sea in an operation called "turning ship" to plot and correct deviation errors of its magnetic compasses.

The design is more compact, and more stable under all conditions. The new-look globe or dome construction which resulted, tends to keep the liquid steady as the vessel rolls and turns. The use of a smaller reading card centralized in the liquid keeps it steady

Courtesy Carboloy News Bureau

Courtesy Carboloy News Bureau

MAGNETIC COMPASS EVOLUTION in the United States is typified (above, left to right) by 100-year-old single bar compass, Ritchie compass, and present improved unit. Two tiny GE Alnico magnets (right), indicated by pencil, allow for a smaller card which is magnified by dome construction. Light spot on disk at right is daub of paint to assure balanced card.

also. The Plexiglass dome top magnifies the card so it appears as large as the compass bowl. A $3^1/_4$-inch card, for example, appears as a 5-inch face.

All of the foregoing changes stemmed from two tiny high-energy GE Alnico V magnets which measure $^1/_4$- by $^1/_8$- by $^1/_8$-inch each.

Manufacturing is simple. The two magnets are simply brazed on opposite sides of a steel ring. A subsequent press operation ends up with a magnet-card unit ready for further compass assembly.

Selective Tone Helps Eliminate Two-Way Radio Chatter

Ear-weary truck drivers and other two-way radio users have been aided by a recent General Electric (GE) development which removes the distracting chatter of radio calls intended for others.

GE engineers have licked this problem by incorporating simple electronic tone selecting equipment in standard two-way radios. The tones turn the mobile radio receivers on individually, thus allowing a dispatcher to communicate with any radio-equipped car or truck without bothering all other radio-equipped vehicles in the network.

The "Personal Channel" system, as it has been designated, has undergone over a year's field-testing. Use of the GE "Personal Channel" allows the same radio range as standard two-way radio systems. Complicated circuits were avoided by the use of tones in the normal voice range of a frequency modulation radio system. Thus, degradation of transmitter signal strength is no problem with a radio system using the "Personal Channel" feature.

There are three basic tone-control parts needed for applying "Personal Channel" to a standard radio system. These are a dispatcher unit for selecting the tones corresponding to mobile units, a tone receiver chassis, and a tone transmitter chassis.

The complete tone dispatching equipment for base station use is housed in a single, small, desk-top cabinet. The cabinet contains 10 push-buttons for selecting one or two tones from a total of 10 different tones. In a small radio system, having 10 or less vehicles equipped with radio, the tones may be used singly for signaling individual vehicles. In larger radio systems, a series of two tones are used for selecting any one of a hundred radio-equipped vehicles.

Two key bars that run the length of the row of 10 push-buttons are used for transmitting. The upper bar is used for transmitting with tone while the lower bar is used for transmitting without tone.

The dispatcher selects the proper tone or tones corresponding to that vehicle's receiver. After depressing the appropriate push-buttons, he presses the Transmit/Tone bar and asks the vehicle to acknowledge his call. When the the vehicle has acknowledged, the dispatcher presses the Transmit (without tone) bar and sends the message. He has virtually the same privacy as if he were using a telephone. In addition, operators of the other vehicles hear only the messages specifically intended for them.

The tone dispatcher unit uses only three tubes and only one tone generator circuit. When a push-button is pressed, it "switches in" a selective network which determines the tone frequency transmitted.

The selective network used in the new GE tone equipment maintains a high degree of stability through the use of a unique feedback type bridged-T circuit not dependent on power. According to GE engineers, the use of electronic rather than mechanical means for determining tone frequency is a more dependable method because there are no moving parts to wear out or become dirty and, thereby, change the tone frequency.

The electrical items for the tone dispatcher unit are mounted as a completely separate unit within the console cabinet. Those electrical items mounted on the face plate, together with the face plate assembly itself, may be lifted out of the way when servicing and yet remain interconnected by a cable. The circuit has been built to select one tone frequency and will not drift.

Depending on the size of the two-way radio system, either a single-tone receiver or a two-tone receiver chassis is used. Both may be used interchangeably with either a base station or mobile radio to which they are are attached with a fast-disconnect type plug.

The tone receivers and transmitters are designed to operate reliably from −22 to 212 F. Thus, even when a mobile unit is in the trunk of a car traveling under the hot sun or in subzero weather, the receivers will not be affected.

The tone transmitter is also designed to maintain a constant tone frequency and a constant output over a battery voltage range of ±25 per cent.

Deep Snow Fields Crossed by Fully Loaded Freight Train

DESIGNED to go across deep snow fields with close to 100,000 pounds of military supplies on its back, a cross-country freight train has just been delivered to the Army Transportation Corps for use above the Arctic Circle.

Designed and built by R. G. LeTourneau, Inc., of Longview, Tex., the block-long carrier travels on 16 of the largest rubber tires in the world. The tires are each four feet wide and 10 feet tall.

Although at first glance the Sno-Train appears to be only a series of flat-bed trailers pulled by a powerful engine car, each "trailer" actually is a self-propelled unit with all-wheel drive (*Electrical Engineering*, January 1956, page 95). This ultimate in both traction and power is achieved by placing a huge electric motor directly in the center of each individual wheel. Should one of the wheels lose traction, its share of the train's total horsepower is instantly

THE SNO-TRAIN, traveling on 16 gigantic tires, rolls easily across expanse of snow more than three feet deep during U. S. Army tests in northern Michigan.

transferred to other wheels which are taking hold.

Because Arctic expanses provide few visible landmarks, a transparent "bubble" is built into the roof of the control car to facilitate navigation by the stars. The same bubble can be used for observation purposes and, in case of emergencies, as a kick-out escape hatch.

Other features which make the train particularly well suited for Arctic travel include: aluminum construction for lightness; ability to operate in temperatures well below zero; preheating facilities for the 600-hp diesel engine; fuel tank capacity of 500 gallons (plus pump for transferring other fuel which may be carried in drums as part of the cargo); and the inclusion of flood lights, winch, and jib crane to aid cargo handling.

The new train is one of the most elaborate off-road transportation and materials handling equipment built, and utilizes the largest tires of any freighter the company has built thus far.

Most Intensely Lighted Street Illuminated by Fluorescent Luminaires

THE "14th Street Businessmen's Association" converted 14th Street between Union Square and Avenue of the Americas into the most intensely illuminated thoroughfare in the City of New York by the use of 22 "V" shaped 8-foot Luxaire fluorescent luminaires mounted on aluminum poles.

These luminaires have a 30-foot mounting height and are on 25-degree elevation with a 25-degree lateral adjustment. Each complete unit has two Luxaires and four 8-foot rapid-start lamps. Each lamp has a life expectancy of 7,500 hours and should burn for at least two years under the worst weather conditions. The average foot-candles for the installation is better than 2 and this soft glarefree type light is so abundant that the accompanying photograph was taken at a 1/10 of a second, stopping vehicular as well as pedestrian traffic.

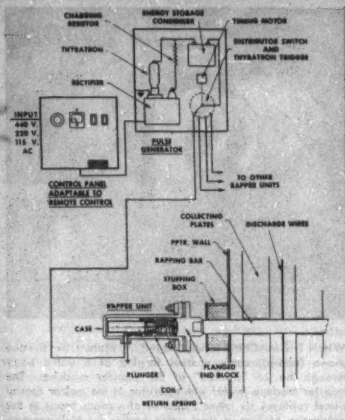
The installation was sponsored by the "14th Street Businessmen's Association," approved by the Department of Gas and Water Supply of the City of New York. The units were installed by Broadway Maintenance and Luxaires, and the poles were supplied by Pfaff and Kendall of Newark, N. J.

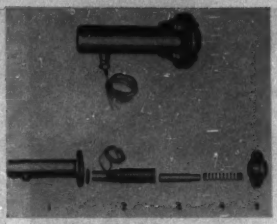
LAMPS (right) installed on 14th Street in New York, N. Y., are 8-foot fluorescent luminaires atop aluminum poles. At night (above) the most brightly illuminated street is photographed with great detail.

Built-in Lubrication for Sealed Impulse Units

A major development project brought into practical reality by materials engineering has been accomplished by the creation of a graphite-impregnated laminated plastics material by the Synthane Corporation of Oaks, Pa. This helped to turn Research-Cottrell, Inc.'s development of improved electrostatic precipitation rapping equipment into a practical reality.

For many years Research-Cottrell has helped large power plants to remove the dust from their flue gases with its electrostatic precipitators that literally pull the dust particles out of the gas stream by use of electrical forces. But occasionally the plates on which this dust collected had to be shaken to dump the collected dust into a hopper. This was generally done by giving the collecting plate a periodic, powerful blow with a "rapper." Often this would stir up a local dust cloud which resulted in a "puff" of fine dust going out of the power plant stacks, which was highly objectionable to the power plant's neighbors. So Research-Cottrell developed a new electronically controlled rapper system which provides small, frequent electromagnetically applied rapping impulses. These impulses continuously remove the collected dust from the collecting plates into a hopper and thus prevent the formation of a thick, collected-dust layer on the plates, which stirs up dust clouds when broken off.





NEWLY DEVELOPED SYSTEM (*diagram*) for removing dust accumulation from electrostatic dust collector plates into a hopper without stirring up a local dust cloud. Electric current pulses are converted to mechanical rapper blows by means of an electromagnetic hammer. Sealed rapper unit (above). Exploded view of rapper (below) shows its functional parts which are (*left to right*): 1, the outside housing; 2, the coil form and coil winding; 3, the plunger; 4, plunger return spring; and 5, end cap.

The new system thus completely eliminates puffs of dust from the stack.

A considerable problem in the development of the new rapping equipment was the need of producing an hermetically sealed electromagnetic hammer that would apply rapping pulses at controlled intervals to the collecting plates and thus produce continuous removal of the accumulated dust.

The frequent blows of this sealed-in hammer required that it be lubricated permanently at the time it was built. Also, the housing had to remain air tight despite the frequent, powerful blows of the hammer, to avoid failure of the hammer from accumulations of the ever-present dust, or from corrosion produced by the corrosive flue gases.

Research-Cottrell engineers referred the problem to Synthane, which devised the following solution. The sealed hammer housing encloses a tubular structure of a laminated phenolic thermosetting plastic. This laminated tubing provides the strength to resist the powerful, repeated impacts of a magnetic core (steel plunger) which is pulled powerfully forward every time a current impulse flows in a magnetic coil wound on the outside of the tube. The sudden movement of the steel plunger delivers a hammer blow to the housing's end piece and this blow is transmitted by a connecting rod to the collecting plates, knocking the collected dust from the plates into the hopper.

To permit the plunger inside the housing to move with a minimum of friction, the tube was lined with a layer of laminated plastic which is impregnated with graphite. The lubricating effect of the graphite permits the hammer plunger to slide back and forth with very little friction, thus provides built-in lubrication from the beginning to the end of the life of the sealed hammer or "rapper" unit.

Research-Cottrell engineers have found that the sealed rapper units using the graphite-impregnated plastic have given such trouble-free service that none of the units produced has ever had to be unsealed, despite the fact that in each one the magnetic core "hammer" may move back and forth as often as 1 to 6 times a minute, or 1,440 to 8,640 times a day for years at a time. And these units have given the same trouble-free service not only in power plants, but also in gypsum, iron cupola, open hearth iron ore sintering, and many other applications.

Valve Manufacture Speeded-Up by Automation

MASS PRODUCTION of precision-machined valve bodies, for higher quality at lower manufacturing costs, is provided by a unique new transfer machine, according to Manning, Maxwell and Moore, Inc., who will use the machine in the Watertown, Mass., plant to manufacture its Hancock gate type high-pressure steel valves. Engineered and built by Baker Bros., Inc., of Toledo, Ohio, at a cost of over $250,000, the machine employs many of the principles of automation for the first time in the valve industry.

The transfer machine replaces six other machines of various types, and requires only one operator. Where the old method produced about 19 finished valve bodies per hour, production with the new machine averages about 73 per hour depending upon size.

Completely automatic and operated from a master control board, the machine has over seven miles of electric wiring and the electric motors produce over 236 hp. When the machine is fully loaded, 30 platens, each carrying a rough forging of a valve body,

Future Meetings of Other Societies

American Society of Refrigerating Engineers, 52nd Annual Meeting, June 3–6, Sherator-Gibson Hotel, Cincinnati, Ohio

SAE, Summer Meetings, June 3–8, Chalfonte-Haddon Hall, Atlantic City, N. J.

Radome Symposium, June 4–6, Ohio Union, Ohio State University Antenna Laboratory, Columbus, Ohio

Edison Electric Institute, Annual Convention, June 4–7, Atlantic City, N. J.

ASCE, Knoxville Convention, June 4–8, University of Tennessee, Knoxville, Tenn.

National Fire Protection Association, Annual Meeting, June 4–8, Hotel Statler, Boston, Mass.

The Materials Handling Institute, 1956 Exposition, June 5–8, Public Auditorium, Cleveland, Ohio

American Nuclear Society, 2nd Annual Meeting, June 6–8, Palmer House, Chicago, Ill.

American Society for Quality Control, 10th Annual Convention, June 6–8, Le Palais du Commerce (Show Mart), Montreal, Que., Canada

S.A.M., National Small Business Conference, June 7–8, Hotel Statler, New York, N. Y.

National Association of Electrical Distributors, 48th Annual Convention, June 10–17, Ambassador and Chelsea Hotels, Atlantic City, N. J.

National Oil Heat and Air-Conditioning Exposition, June 11–15, The Coliseum, New York, N. Y.

International Council of Scientific Unions, 4th Meeting, June 11–15, Ohio State University, Columbus, Ohio

SPI, Conference and Annual Meeting, June 11–15, Commodore Hotel, New York, N. Y.

Annual Colloquy of College Physicists, June 13–16, University of Iowa, Iowa City, Iowa

Amateur Radio Relay League, West Gulf Division Convention, June 15–17, Galveston, Tex.

ASME, Semiannual Meeting, June 17–21, Hotel Statler, Cleveland, Ohio

ASTM, 59th Annual Convention, June 17–22, Chalfonte-Haddon Hall Hotel, Atlantic City, N. J.

Acoustics, 2nd International Congress, June 17–24, Massachusetts Institute of Technology, Cambridge, Mass.

Material Handling Training, 3rd Annual Conference, June 17–30, Lake Placid, N. Y.

American Society of Heating and Air-Conditioning Engineers, Inc., Semiannual Meeting, June 18–20, Washington, D. C.

Human Engineering Institute, 4th Annual Seminar, June 18–22, Stamford, Conn.

ASEE and National Science Foundation, Conference on Mathematics in Engineering, June 20–22, University of Michigan, Ann Arbor, Mich.

American Physical Society, Annual Convention, June 21–23, New Haven, Conn., and Eugene, Ore.

Stanford Research Institute and University of California, joint Symposium on Methods, Materials, and Processes involved in the Uses of High Temperatures in Science and Industry, June 25–27, Berkeley campus, University of California, Berkeley, Calif.

ASEE, Mathematics Division Annual Meeting, June 25–29, Iowa State College, Ames, Iowa

SPI, Plastics Structures Division Conference, June 26, Hotel Roosevelt, New York, N. Y.

American Association of Railroads, Mechanical Division Convention, June 26–28, Sherman Hotel, Chicago, Ill.

Western Summer Radio-Television and Appliance Market, July 16–20, Western Merchandise Mart, San Francisco, Calif.

ASCE, National Hydraulics Division Annual Meeting, August 22–24, University of Wisconsin, Madison, Wis.

WHEN THE MACHINE is fully loaded, 30 platens, like the one shown (above), carry a steel forging of a valve body through the 26 "stations" of the transfer machine. The transfer machine (*right*) with operator at the master control panel replaces six other machines of various types in the production of forged steel valve bodies for high-pressure gate type Hancock steel valves.

pass through a total of 26 "stations." There are 10 drilling, 4 reaming, 6 tapping, 2 precision boring, 2 facing, 1 counterboring, and 1 broaching operations which occur simultaneously when the machine is cycled. All chips from the forgings are disposed of automatically by a conveyor, while all units and moving parts are lubricated automatically by a central lubricating system.

Change-over time from one size valve body to another is kept to a minimum by the design of tooling and spindle ends that keep the settings of feeding units constant from one size to another. Size of the high-pressure steel valve bodies machined vary from 1/4 through 2 inches.

The rectangular construction has several advantages, including compactness and floor space requirements, as well as having everything within easy proximity to the operator. The machine is manufactured in Baker Bros. plant in Toledo, Ohio.

Device Measures 400,000 F Temperatures

For the first time under laboratory conditions, man has produced temperatures of well over 400,000 F and corresponding brightness 700 times greater than at the surface of the sun.

The incredible temperature and subsequent brightness were a result of investigations into the physics of high energy, high temperature gaseous discharge by scientists of the Air Research and Development Command (ARDC).

This important work has been accomplished in connection with the classified ARDC project at Air Force Cambridge Research Center. However, the technique itself is not classified, and holds promise of possible use for industrial and research organizations.

Temperatures which have been measured by the laboratory are of exceedingly short duration, less than a millionth of a second, but an important outgrowth of this research was the design of equipment capable of accurately measuring the powerful and extremely fast pulsed electrical spark discharge.

The extremely high temperatures involve the release of electric energy into a very small volume of inert gas under high pressure.

A specially designed capacitor circuit is employed to store the energy and release the electric discharge. This capacitor circuit, applied to the basic gaseous discharge technique, is primarily responsible for the resultant high temperatures.

In the past, those working in the field were unable to determine with accuracy the temperatures which they were able to generate. Now, because of ARDC's newly devised equipment, an accurate measurement of the temperature and the brightness is calculated.

These experiments and the resulting measuring devise were conducted by Dr. Heinz Fischer, chief of the electro-optical section at the Cambridge Research Center.

Transistorized Units To Go on First U. S. Turbo-Props

American Airlines' new fleet of Lockheed-Electra 400-mile-an-hour airliners will be equipped with a completely transistorized automatic flight system developed by Bendix Aviation Corporation.

The transistorized systems for the airlines' four-engine, turbo-prop planes scheduled to go into service beginning August 1958, represent commercial aviation's first decision on the type of automatic flight control needed to meet the U. S. requirements of the turbo-prop and turbo-jet age.

Turbo-prop engines operate on the same principle as straight jets, except that the engine turns a propeller.

The all-transistorized flight system will equip American's new 66-passenger transports with an automatic control system that flies the planes unerringly on radio-marked flight paths and makes automatic ILS (instrument landing system) approaches to airports. It also provides for automatically steering the plane by electronic signals coming from a directional gyro that is in turn constantly cross-checked by a magnetic compass. The system is designed, the announcement said, for super-accurate control under all flight conditions, with resulting savings in fuel consumption, improved standards of flight-schedule regularity and increased passenger comfort.

Linked to the control system are newly designed indicators providing on just two dials all of the essential information the pilot needs to make sure the plane is "on course." Meantime he is free to watch, or monitor, other aspects of the flight. Just by turning a knob he can take over manual control at any time.

The entire system is equipped with transistors which have overwhelming advantages in aircraft applications, instead of vacuum tubes. They use substantially less power, create no heat problem, occupy very little space and, most importantly, are practically indestructible.

Courses Are To Be Given in Automation and Guided Missiles

An intensive course in how to design and "tool up" products and manufacturing equipment for low-cost automation will be held at The Pennsylvania State University, University Park, Pa., June 10–15.

The week-long course is intended for manufacturing and product design engineers in medium and small volume manufacturing organizations.

Approximately one half of the course will be devoted to workshop sessions dealing with processing, process integration, tooling, hardware design and selection, controls, and product design.

Other sessions will stress various aspects of product design for automation, methods of systems analysis and planning, tooling and integrating automation systems for small, medium, and job shop operations.

Special attention will be given to methods

of designing low-cost systems for manufacturers having limited tooling budgets through the selection and integration of standard tools and hardware into existing equipment.

A comprehensive course in the field of guided missiles will be offered at The Pennsylvania State University, July 2-13.

The two-week lecture and practicum course will be taught at the graduate level to provide a broad introduction to torpedo engineering. In addition, the course will serve as a practical case study of the application of systems approach to solution of over-all guided-missile design problems.

This course will be especially valuable to engineers, scientists, naval officers, and administrators associated with torpedo research, developments, and engineerings. It is designed also for those wishing an introduction to the practical application of systems engineering in solving complex engineering problems.

The fundamental principles underlying the design synthesis of underwater guided missiles will be discussed, including acoustic, electronic, hydrodynamic, control, and propulsion areas.

Text material and demonstrations have been prepared by nationally and internationally known specialists, who will be available throughout the course for discussion. The course will be organized and taught by the Ordnance Research Laboratory at Penn State, the only civilian academic institution concerned with the over-all problem of torpedo research and development.

The material will be co-ordinated into a consistent, uniform series of lectures, demonstrations, and field work.

AEC Announces Gem Irradiation Policy

The U. S. Atomic Energy Commission (AEC) has announced that requests for irradiation of gems in Commission facilities will be treated in the same manner as requests for irradiation of other materials. The AEC's recent decision removes a suspension of gem irradiations which has been in effect since 1953.

It has been known for more than 50 years that color changes may be produced in gems by irradiation. Radium, and more recently particle accelerators, cobalt-60, and nuclear reactors have been used for this purpose. Radiations from a particle accelerator may produce blue or blue-green colors in diamonds. Irradiation in a nuclear reactor may produce a green color, which may be turned to brown under certain conditions of heating.

In April 1953, the Commission temporarily suspended the issuance of authorizations for irradiation of diamonds and other gems in all AEC facilities pending study of the policy involved in such irradiations. As a result of the study, it was decided that requests for gem irradiations should be handled in the same manner as other requests for service irradiations. Commission policy is to authorize irradiations when reactor space is available. A fee covering the cost of providing the irradiation service is charged.

It was noted by the AEC that "Trade Practice Rules for the Diamond Industry" were published by the Federal Trade Commission on February 10, 1956. The rules, which went into effect on March 10, 1956, provide in part:

> "*Deception as to Color.* . . .It is an unfair trade practice to advertise, offer for sale, or sell any diamond which has been artificially colored or tinted by coating, irradiating, or heating or by use of nuclear bombardment, or by any other means, without disclosure of such fact to purchasers or prospective purchasers, or without disclosure that such artificial coloring or tinting is not permanent if such is the fact."

Diamonds irradiated in a nuclear reactor become radioactive temporarily, but the radioactivity decays to an insignificant level within a few days.

Highest Steam Temperature Turbine-Generator Unit Running

With the recent completion of the new 200,000-kw steam turbine-generator unit at Burlington (N. J.) Generating Station, located on the Delaware River, the Public Service Electric and Gas Company's electric system capacity has been increased to 2,104,300 kw. On completion in 1957 of two other generating stations, the Linden and Bergen installations, the total effective generating capacity of the company's seven stations will approximate 3 million kw.

The objectives in the design of the new Burlington unit were to achieve one which would be simply arranged, with central control to reduce operating effort, and a steam cycle to take advantage of high steam temperature and pressure. About 1.25 million pounds of steam an hour can be produced at a pressure of 2,350 pounds per square inch and a temperature of 1,100 F, which is still the highest steam temperature for power generation in operation in this country. The steam turns the 107-ton 105-foot shaft of the turbine-generator so fast that the outer rim of the turbine spindle is moving at a speed of 1,075 miles an hour, or 50 per cent faster than the speed of sound. To generate steam at full capacity over 270,000 gallons of oil or 1,550 tons of coal are burned every day.

NEW 200,000-KW TURBINE-GENERATOR has been added to Public Service System to keep pace with ever-increasing demand for electric energy in New Jersey's Delaware Valley.

The new structure for the unit consists of boiler house, turbine room, pulverizer bay, and electric equipment bay. The boiler, as tall as an 11-story building, is of the semi-outdoor type which not only reduces the duty of the ventilating system, but also results in a considerable saving in building cost. An interesting structural feature is that this 3,250-ton boiler is suspended from a supporting steel frame. When the boiler is hot, it expands downward in length about 6 inches. Features of the new reheat boiler include pressurized firing, flue-gas recirculation and tempering, and high steam temperatures and pressures. The feedwater heating cycle includes eight stages of heating with six heaters and four drain coolers on the suction side of the boiler feed pumps.

The turbine-generator is a tandem-compound 3,600-rpm machine consisting of a high-pressure section, a reheat single-flow intermediate-pressure section, and a triple-flow low-pressure section. Fresh water from the Delaware River amounting to 121,400 gallons per minute is used to condense the exhaust steam in the condenser. The water, condensed from the steam, is pumped through various pieces of equipment, where it is heated before it re-enters the boiler to be turned into steam again and start another round trip.

The electricity is generated at 13,800 volts in the generator, which is cooled by hydrogen gas under 30 pounds per square inch pressure. The use of hydrogen permits an output 25 per cent more than if the generator were cooled by air. The tandem-connected auxiliary generator is rated at 15,625 kva or 12,500 kw at 0.80 power factor.

CENTRAL CONTROL ROOM for new turbine-generator unit has approximately 350 instruments and controls.

All of these processes involved in the generation of electricity by this unit are coordinated by two men stationed in a central control room. Approximately 350 instruments and controls, more than the number in a modern 4-engine commercial airliner, keep the operators constantly informed of the operating conditions of the boiler, turbine, generator, and other auxiliary machinery. Approximately 450 different operating conditions are being constantly recorded on charts. In addition, 550 indicating lights tell operators of the proper functioning of equipment.

Transformers raise the voltage for economical transmission through the 132,000-volt transmission system, which is the "backbone" of the electric supply for the company's territory. From 14 switching stations, located on this high-voltage system, subtransmission at 26,400 volts delivers energy to 155 company substations. The Public Service System is interconnectedwith those of neighboring utilities and is thereby part of an interconnected electric system with an installed capacity of almost 8.6 million kw.

International Meetings Cover Many Engineering Phases

World Power Conference: This fifth meeting is to be held in Vienna, Austria, from June 17–23. Preprints of the technical papers and of the general reports are available free from the Austrian National Committee.

International Electrotechnical Commission: The annual meeting of IEC is scheduled from June 27 to July 6 at Munich, Germany. Inquiry should be made to the United States National Committee, c/o American Standards Association, 70 East 45th Street, New York, N. Y.

International Organization for Standardization: The meeting of the Council will take place from July 16–21 at Geneva, Switzerland.

Convention of Engineers and Architects: An international convention of Engineers and Architects, Friends of Israel, is to be held in Tel-Aviv, Israel, during the month of August. Additional information may be obtained either from the American Technion Society, 1000 Fifth Ave., New York, N. Y., or Association of Engineers and Architects, 200 Dizengoff St., Tel-Aviv, Israel.

Congress of Applied Mechanics: The 9th International meeting will take place at the University of Brussels, Brussels, Belgium, on September 5–13. There will be technical sessions covering the fields of fluid dynamics, aerodynamics, and mechanics of solids (rigid dynamics, vibrations, elasticity, plasticity). Registration can be made at any of the Atomic Energy Commission offices throughout the country. Brochures may be obtained from the Secretary, The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y.

Canadian IRE Convention: Elaborate arrangements have been made for the 1956 Canadian IRE Convention celebrating the 30th Anniversary of the organization, October 1–3. In conjunction with the convention will be an Electronic Exposition at the Automotive Building in Exhibition Park in Toronto, Ont., Canada. Every phase of electronics will be covered including industrial applications.

Chemical Industries Conference: The 29th International Chemical Industries Congress, the 1st European Corrosion Congress, and the Conference on Basic Chemicals in conjunction with a Plastics Materials Exposition will take place in Paris, France, from November 22 through December 3. Additional information is obtainable by writing to: Rassemblement des Arts Chimiques 1956, IV° Salon de la Chimie, Caoutchouc—Matieres Plastiques, 28, Rue Saint-Dominique—Paris-7°, France.

Public Works Congress and Exhibition: "London Calls," a brochure explaining the Public Works and Municipal Services Congress and Exhibition, 1956, is available from The Municipal Agency Limited. Anyone interested in attending should plan to be in London, England, November 12–17.

Floodlight Has Color-Improved Lamps

One of the first floodlights designed specifically for "color-improved" mercury vapor lamps has been announced by Wilson Electrical Equipment Company of Houston, Tex.

Called "Wide-Lite," the new unit provides a broad, complementary pattern that can be overlapped smoothly to provide area coverage without hot spots or valleys of shadow. Lateral light spread is 130 degrees and vertical spread is 40 degrees.

Wide-Lite installations require 47 per cent less power than those utilizing conventional incandescent lamps, and the units may be operated on 220 or 440 volts to cut installation wiring costs. Relamping maintenance is drastically reduced, because lamp life is six times that of incandescent floodlights, and fewer units are needed to properly light a given area.

Rectangular in shape to complement both the length and the diameter of the light source, Wide-Lite has a cast aluminum alloy enclosure. Trapping of light behind the lamp is prevented by a unique "butterfly" reflector made of brilliant alzak aluminum. Airplane type fins are used for heat dissipation, and the unit has a pyrex glass lens. A baffle prevents leakage of light that has not been color-corrected, and the unit is completely sealed to insure long reflector life.

Wide-Lite offers an entirely new approach to many lighting problems. Industrial interiors and warehouse aisles may be illuminated to distances never before possible and building exteriors can be lighted dramatically without dark areas to mar the over-all effect. On outdoor advertising signs, one Wide-Lite will usually do the work of five conventional light sources.

WIDE-LITE unit gives lateral light spread of 130° and can be operated on 220 or 440 volts, thus cutting installation costs.

Magnetic Tape Records and Reproduces TV Programs

A new process for the recording and reproduction of television programs on magnetic tape was demonstrated in Chicago by G. I. Long, president of Ampex Corporation and in one of the engineering laboratories at Redwood City, Calif., by A. M. Poniatoff, chairman of the Board of Directors. The Video Recorder can record and reproduce an hour's program on a 14-inch reel of 2-inch magnetic tape.

The new Ampex VTR (video tape recorder) system records both picture and sound on a single magnetic tape two inches wide. Picture quality is considered to be better than that obtained with current kinescope techniques using photographic film. The "gray scale"—the ability to reproduce accurately all shades from black to white, is inherent in this new video magnetic tape recording system. On the other hand, the gradient from black to white is not uniform in photographic film.

Resolution is measured by the number of lines into which a television screen is divided, the greater the number of lines (the finer the lines) the more detail appears in the picture. Horizontal resolution is a variable depending on many factors, most limiting of which is the television receiver. An average home receiver has a horizontal resolution of approximately 275 lines across the face of the picture tube. The maximum number of lines which a station can transmit is 340. The Ampex VTR will record and reproduce more than 320 lines.

Perhaps even more important than the reproduction of recorded programs with "live" telecast quality are the operational and economic advantages the Ampex VTR can offer to the vast television industry. Programs can be recorded directly from the television camera, from a television receiver, from television transmission lines, or from microwave relay systems. Just as with the Ampex audio tape recorders, the program can be immediately replayed with no processing of any kind necessary. Considerable economy can be effected by the erasing and re-using of tape to record another program. This is in contrast to photographic film which cannot be re-used after it has once been exposed.

Once the equipment has been installed and adjusted, operation is as simple as that of an Ampex audio tape recorder. To record a program, the operator presses one button to start recording. To play a recorded program, he simply presses the playback button.

The machine operates on the same basic principles employed in a regular Ampex audio tape recorder. Electrical signals are passed through a coil around an electromagnet, the recording head. The strength of the magnetic field in the recording head at any time depends on the electric current in the coil at the given instant. In turn, the magnetic field impresses a pattern on the magnetic surface of the tape as it passes the recording head. The pattern on the tape, therefore, corresponds to the electrical signals in the coil on the recording head. Inasmuch as the electrical signals are generated by the television camera, the pattern on the tape corresponds to what the camera "sees" at any given instant.

To reproduce the picture, the tape is passed across the same magnetic head. The magnetic pattern on the tape induces a current in the coil around the head. Since the pattern corresponds to the original picture, the induced current can be fed to a television transmitter just as though it were coming directly from the television camera.

To obtain the resolution of 320 lines, Ampex's VTR must record frequencies as high as 4 mc. Sound magnetic tape recorders need only record frequencies as high as 15,000 cycles per second. Present day magnetic recording techniques demand that, to increase frequency response, the tape must be moved past the head at higher rates of speed. To obtain a frequency response of 15,000 cycles per second, Ampex audio tape recorders use a tape speed as low as $7^1/_2$ inches per second. By direct ratio, to obtain the 4-megacycle response needed for video recording, tape speed would have to be 2,000 inches per second. At that rate, a reel of magnetic tape 14 inches in diameter would record only 29 seconds of program material.

Ampex engineers have developed a system which permits a tape speed of only 15 inches per second, permitting more than a full hour's program to be recorded on a single 14-inch reel of tape. To achieve this relatively low tape speed a magnetic head assembly which rotates at a high speed is used, giving an effective tape speed sufficient to record and reproduce the full 4-mc band width. Thus, while the tape moves slowly, the heads move across the surface of the tape at a very high speed. The head assembly actually consists of four heads placed on a rotating drum. One head is always in contact with the surface of the tape. As one head leaves the tape, the next head makes contact. The magnetic pattern is recorded transversely across the tape instead of longitudinally as in conventional audio recorders.

The sound that accompanies the picture is recorded in the ordinary manner along one edge of the magnetic tape.

At the Chicago meeting, held in conjunction with the annual meeting of more than 200 CBS Television network affiliate officials, it was announced that CBS Television has placed an order for the first three prototype units. Delivery to CBS will be completed by late summer, according to P. L. Gundy, manager of Ampex's Audio Division, responsible for the development.

MAGNETIC HEAD assembly is being inspected by C. P. Ginsburg, senior project engineer in charge of video development, and P. L. Gundy, manager of the audio division, responsible for Ampex Corporation's new television tape recorder.

High-Speed Electronic Missile Test Device Developed

Delivery of a high-speed testing device which electronically simulates the conditions of firing of a guided missile while it undergoes production tests was disclosed by the Electronic Engineering Company of California (EECO), Los Angeles, Calif. The equipment was designed and constructed with the co-operation of the Hughes Aircraft Company, Tucson, Ariz., and is to be used in the testing of the FALCON missile at the Hughes Tucson plant.

While it is not possible to reproduce the actual conditions of launching, the test device will indicate as accurately as possible without firing whether the missile will fulfill its mission.

The basic design philosophy and outline specifications for the equipment were prepared by the test equipment engineering department of Hughes. From this data EECO designed and built the test equipment.

Under pressure of mass production conditions, the high-speed device goes through a predetermined schedule of tests, indicates unsatisfactory tests by means of a series of lamps, checks on its own accuracy, and records the test results on a punch card.

Special features of the missile test equipment include:

(1) Each step of the testing operation is automatically programmed. As each operation is performed in the checking out of the missile's electromechanical and electronic functions, the equipment proceeds to the next test if it receives a satisfactory answer. However, if the test is unsatisfactory, the sequence is interrupted and the test giving trouble is indicated by a lamp.
(2) A self-checking feature enables factory test personnel to check quickly and automatically against built-in standards and to have a date-stamped record of the results.
(3) Each test result is qualitative, with the punched card indicating whether the missile is: (a) far above the top limit of the standard, (b) above but close to the top limit of the standard, (c) inside but close to the top limit, (d) inside but close to the bottom limit, or (e) far below the bottom limit.
(4) The device may be instantly modified for different missile models by inserting prewired plugs to alter the test sequences.
(5) The construction and components are designed to minimize failures and breakdowns under factory testing conditions. For example, the stepping switches (similar to those used in dial telephone systems) which perform the sequencing operations are sealed in an oil bath.

Special Offerings of Several Educational Institutions

10-Day Systems Engineering Course: Purdue University will conduct a series on Linear Automatic Control System Synthesis from July 9–20. Feedback theory, from the signal-flow viewpoint, root locus methods approximations in time and frequency, etc., are to be covered. The course is intended for engineers who are interested in advanced control system theory and for teachers.

Summer Molecular Engineering Session: A part of the 1956 summer session at the Massachusetts Institute of Technology will include a program to clarify the mode of thinking "from the inside" in discerning the elementary particles and their interplay in gases, liquids, and solids. Participants will be limited in number, and dormitory rooms will be available for registrants. Applications are obtained from Summer Session Office, Room 7-103, MIT, Cambridge, Mass.

X-Ray Diffraction: Two Norelco X-ray diffraction schools will be sponsored free by Instrument Division of North American Philips Company, Inc. The first week-long session will be held at the Hotel Morrison, Chicago, Ill., from June 4–8. The other one will be given at the Sir Francis Drake Hotel, San Francisco, Calif., from September 24–28.

Automation Seminar: Product designers, manufacturing engineers, and management from small industries, who want to decide whether they should get started in automation, will be interested. Those who attend will be told how to integrate standard catalogue equipment, hardware, and controls when tooling up. The sessions will be held on campus The Pennsylvania State University, from June 10–15, at University Park, Pa.

Electronic Data-Processing Methods: At two one-week sessions held August 6–10 and August 13–17, a special summer program course will be given in Electronic Computers and Business Problems by the Massachusetts Institute of Technology. Detailed facts will be on: what a computer amounts to; the nature of commercially available computers; suitable areas within the data-processing system which must be selected, analyzed, and programmed; programs which must be coded in detail so that the computer can perform the desired work; and other related topics. Details available from Summer Session Office, MIT, Cambridge, Mass.

Operations Research: A course to provide a short intensive survey of methods, techniques, and tools, with emphasis on applications in business and industry. The two-week course is given at Case Institute of Technology beginning June 4th and ending June 15th.

Reactor Training School: The Atomic Energy Commission has made arrangements with The Pennsylvania State University and North Carolina University, both of which have research reactors, to train 62 students including 47 from 23 foreign countries in a 10-month session including

unclassified courses in design, construction, and operations of reactors for nuclear research.

Statistical Methods in Industry. The department of engineering of the University of California, Los Angeles, co-operating with University Extension and the Los Angeles section of the American Society of Quality Control will have two concurrent courses; a basic course in quality control by statistical methods and an advanced course in industrial statistics. Classes will be in session from 8 a.m. to 5 p.m. from August 6–17.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

PLASTICS PROGRESS 1955. Papers and discussions at the British Plastics Convention of 1955. Edited by Phillip Morgan. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 1956. 432 pages, 6 by 9¼ inches, bound. $17.50. Recent developments in many fields of plastics technology are covered in papers grouped under the following headings: polymer structure and properties, expanded plastics, thermoplastics, extrusion, work study and productivity, injection molding, patents, foundry resins, and glass reinforced plastics.

POWER SYSTEM PLANT. Edited by E. O. Taylor. George Newnes Limited, London, 1955. Available in the United States from Transatlantic Arts, Inc., Hollywood-by-the-Sea, Fla. 307 pages, 5½ by 8¾ inches, bound. $7.25. Based on a series of lectures for advanced students and practicing engineers, this book consists of eight chapters, each by an engineer closely connected with the theory or practice of the subject covered. The book deals with synchronous machines of the salient pole and nonsalient pole type; load, frequency, and excitation control of synchronous machines; and transformers, reactors, and voltage regulators. Two chapters are devoted to switchgear principles and practices, and two to underground cables and overhead lines.

PROCEEDINGS OF THE RETMA SYMPOSIUM ON AUTOMATION. (University of Pennsylvania, September 1955) Sponsored by the Engineering Department of the Radio-Electronics-Television Manufacturers Association. Engineering Publishers, GPO Box 1151, New York 1, N. Y., 1956. 114 pages, 8½ by 10½ inches, paper. $5. The papers in these proceedings deal chiefly with automation for high volume assembly and low volume production, data processing and utilization, and redesign for automatic production. Some of the specific subjects discussed are automatic production of electronic assemblies, automatic warehousing, factory automation by digital control, and production of electronic circuits by mechanized wiring. The proceedings also include a panel discussion on the future of automation.

THE RADIO HANDBOOK. Edited by W. I. Orr. Editors and Engineers Limited, Summerland, Calif., Fourteenth edition, 1956. 761 pages, 6½ by 9½ inches, bound. Available through the radio trade at $7.50, from the publisher at $8.25. Principles of equipment design and signal propagation in the field of short wave or high frequency radio are stressed in the new edition of this standard work. The 32 chapters cover basic circuit elements and theory as well as the design of oscilloscope receivers, transmitters, amplifiers, antennas, and other equipment. The last chapter reviews mathematics necessary to understand and apply the information given.

THE REPORT ON UNIDENTIFIED FLYING OBJECTS. By E. J. Ruppelt. Doubleday and Company, Inc., Garden City, N. Y., 1956. 315 pages, 5½ by 8½ inches, bound. $4.50. The author, formerly head of the Air Force project to investigate reports of unidentified flying objects, reviews some of the thousands of cases analyzed by his staff and gives an account of the findings which ranged from identification of the objects sighted as ballons, aircraft, or astronomical bodies, to rejection of the reports as hoaxes. A number of reports classified after investigation as "unknowns" are discussed in detail.

TECHNIQUE ET UTILISATION DES JAUGES DE CONTRAINTE. By U. Zelbstein. Dunod, Paris, France, 1956. 255 pages, 5½ by 8¼ inches, bound. F frs. 1880. This treatise on strain gauges gives detailed coverage of both the research and practical aspects: physical and electrical characteristics, methods of operation, methods of application, various types of equipment, and specific examples of use.

ADVANCES IN ELECTRONICS AND PHYSICS. Volume VII. Edited by L. Marton. Academic Press, Inc., 125 East 23rd Street, New York 10, N. Y., 1955. 527 pages, 6 by 9¼ inches, bound. $11.50. This volume covers a wide range of subjects in electronics, electron physics, and related solid-state phenomenon in separate papers grouped under the following headings: the physics of semiconductor materials; theory of electrical properties of germanium and silicon; characteristic energy losses of electrons in solids; sputtering by ion bombardment; observational radio astronomy; analogue computers; and electrical discharge in gases and modern electronics. An extensive list of references accompanies each group of papers.

1955 BOOK OF ASTM STANDARDS INCLUDING TENTATIVES. Published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. Part 1, Ferrous Metals, 1,834 pages, $13.50; Part 2, Non-Ferrous Metals, 1,516 pages, $11.00; Part 3, Cement, etc., 2,062 pages, $13.50; Part 4, Paint, etc., 1,416 pages, $11.00; Part 5, Fuels, etc., 1,496 pages, $11.00; Part 6, Electrical Insulation, etc., 1,776 pages, $13.00; Part 7, Textiles, etc., 1,692 pages, $11.00. Complete set, seven volumes, 6 by 9¼ inches, bound. $84. The triennial publication of the complete standards of the Society. The seven volumes include over 2,000 specifications, tests, and definitions of terms of which 1,158 are new or revised since 1952. Each of the volumes contains a detailed subject index, as well as a list of standards in numeric sequence. A separate index covering all the volumes is provided with each complete set. To keep the book up to date, supplements to the various parts will be issued in 1956 and 1957.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Television, How It Works, 2nd Edition. The only prerequisite for getting the most from this book by J. R. Johnson is a rudimentary working knowledge of electricity and radio circuits. It covers television receivers in general, as is now possible because of the stabilization of circuits in use today. The book covers each of the several parts of a receiver, from the antenna to the picture tube, a chapter to each. The fundamentals of a color television receiver are treated in the last chapter. The book is 5½ by 8½ inches in size. 352 pages. $4.60. Order from John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y.

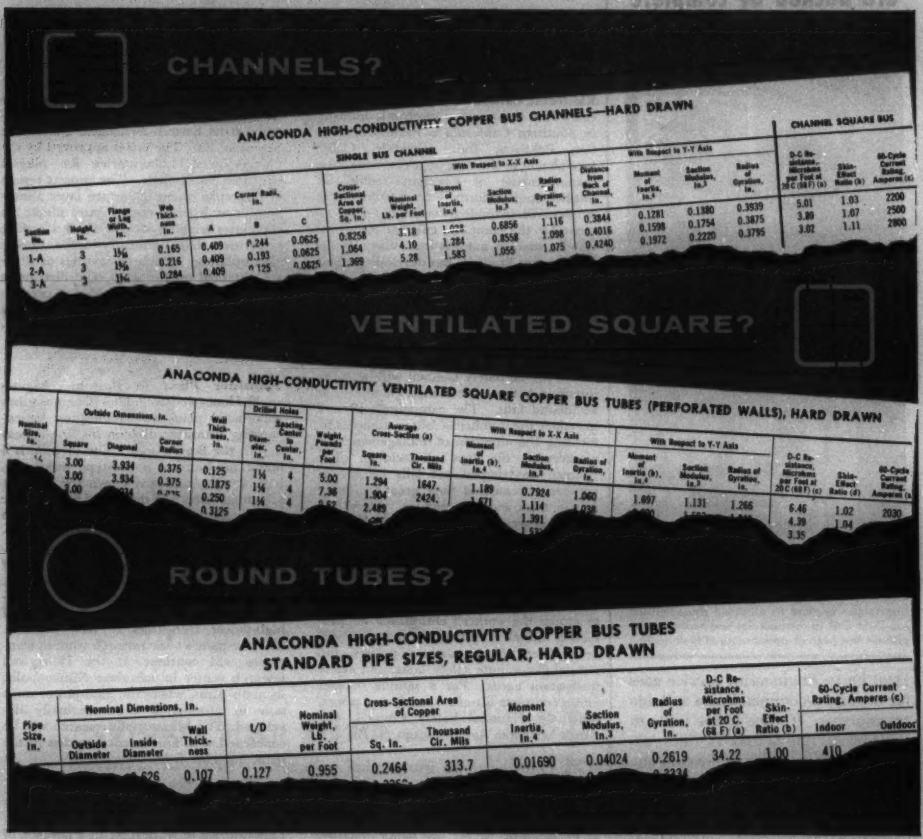
The Engineering Societies Directory. A complete list of all engineering societies in the United States, together with pertinent information about them, will be published by Engineers Joint Council (EJC) tentatively as of June 1, 1956. The Directory will be a new publication, not a revision, of the Engineering Societies Yearbook, which was published in 1948 and has been discontinued. Questionnaires, mailed to all known societies, should be returned to EJC by March 1. If a society has not received such a questionnaire by that time, it should contact Engineers Joint Council, 29 West 39th Street, New York City. The Directory will be the only complete listing of engineering socicites at all levels and will be available at $3.50 per copy.

Discontinuities in Open-Wire Lines, PB 111700. A correction for the variations in the parameters of the transmission line or termination is discussed in this report of electrical research by the U. S. Navy. The report has just been released to industry by the Office of Technical Services (OTS), U. S. Department of Commerce. According to the report, the discontinuities in open-wire lines may be rectified by introducing junction-zone networks of lumped series and shunt elements which may be evaluated for each discontinuity. Junction-zone networks are obtained for a bend, a shunt T-junction, and series T-connections with applications to certain types of antennas in an otherwise uniform two-wire line or single-wire over an image plane. This report extends the work of previous investigation in the sense that a simple closed formula is obtained which, while restricted in range, applies with reasonable accuracy to most lines used in practice. The report by Harvard University for the Office of Naval Research, July 1954, is available from OTS, U. S. Department of Commerce, Washington 25, D. C. Price, $1.75. 62 pages. It contains figures and references.

The Use of Selenium Photocells and Sun Batteries. By John Sasuga. This guide for technicians, experimenters, and engineers in science and industry contains the basic theory and typical applications of photovoltaic cells. Typical photoelectric devices may contain relays, transistors, or other components, which together with the photoelectric cell make possible their operation. The technique of integrating these various components into a practical device involves a special technology and some knowledge of the basic principles of photoelectricity. It is the purpose of this book to present the necessary knowledge and technology and to apply them to many interesting and practical devices. The main topics covered by the chapters of this booklet are light-powered devices; light sources and beam illuminators; photoelectric relays, simple connections; photometers; unusual relays; ultra sensitive relays; and light beam communication. 58 pages, including appendix and bibliography. $1.50. Available from electronic parts distributors throughout the country or may be ordered directly from International Rectifier Corporation, 1521 East Grand Ave., El Segundo, Calif.

Proceedings of the World Symposium on Applied Solar Energy. First distribution is to the 800 registrants to the symposium, held last November in Phoenix, Ariz. Published by Stanford Research Institute for the Association for Applied Solar Energy, it contains 30 papers by internationally recognized authorities on solar energy. Subjects include solar water heaters, solar collector design, solar energy conversion, and algal culture studies. An opening 7-page section contains pictorial highlights of symposium sessions and of the Solar Engineering Exhibit, held in conjunction with the symposium. The final section of the proceedings is a summary of the concluding session, a round-table discussion, which dealt with "The Future of Applied Solar Energy." 300 pages. $5, postpaid. Orders should be directed to Mr. John I. Yellott, secretary for the Association for Applied Solar Energy, 204 Heard Building, Phoenix, Ariz.

Which Bus Shape for Your System?


CHANNELS?
ANACONDA HIGH-CONDUCTIVITY COPPER BUS CHANNELS—HARD DRAWN
SINGLE BUS CHANNEL
CHANNEL SQUARE BUS
VENTILATED SQUARE?
ANACONDA HIGH-CONDUCTIVITY VENTILATED SQUARE COPPER BUS TUBES (PERFORATED WALLS), HARD DRAWN
ROUND TUBES?
ANACONDA HIGH-CONDUCTIVITY COPPER BUS TUBES
STANDARD PIPE SIZES, REGULAR, HARD DRAWN

The table headings above are typical of the new information just published by The American Brass Company—to help make the selection of bus conductors easier and quicker. There are comparable tables for other rigid bus conductor shapes in the more commonly used sizes. In addition, convenient data is available for bare copper wire and cable and the most widely used Anaconda alloy wires.

For preliminary analysis—for many normal jobs—this new information can save you time, eliminate lengthy calculations. You'll find it in the brand-new Fifth Edition of The American Brass Company's 62-page Publication C-25, "Anaconda Copper for Electrical Conductors," which has much hitherto unpublished information to help you.

The services of The American Brass Company's Technical Department are available to help you in the solution of special problems involving the use of Anaconda Bus Conductors. For such help—or for a copy of "Anaconda Copper for Electrical Conductors"—see your nearby Anaconda representative. Or write: The American Brass Company, Waterbury 20, Conn.

56101

ANACONDA® COPPER CONDUCTORS

THERE'S AN ANACONDA ELECTRICAL CONDUCTOR FOR EVERY NEED

Hevi Duty Transformers are backed by complete engineering service

Ace Central States Machine Tool Company, Detroit, uses a Hevi Duty Transformer on this control panel, designed and built for one of America's best known companies. They chose this transformer because its electrical characteristics are right and its compact size and neatness compliment the over-all appearance of high quality.

Hevi Duty Engineering service goes far beyond recommending a suitable transformer. If none of the units in their broad line is exactly right, experienced engineers will develop one that meets your requirements in every detail. Further, they are geared to swing quickly from specialized development to full-scale production.

This combination of a broad standard line, complete engineering service plus the ability to go into production quickly has proved valuable to many Hevi Duty customers. We invite you to take advantage of this service.

Write for Bulletin HD-499 for details on standard Hevi Duty Transformers from 2 VA to 2,000 KVA or describe your special requirements.

HEVI DUTY

HEVI DUTY ELECTRIC COMPANY

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Heat Treating Furnaces . . . electric exclusively
Dry Type Transformers
Constant Current Regulators

INDUSTRIAL NOTES . . .

Electronic Cable Manufacture. A recent entry into the growing electronic industry in Southern California is Pacific Automation Products, Inc., Glendale, Calif., specializing in the design, engineering, and manufacturing of electronic cable for missiles and industry. In keeping with emphasis on individual component development for the complex, efficient electronic systems used in automation today, Pacific Automation Products has developed a new concept: treat the inter-unit electronic cable as component, complete with connectors, ready to install.

Campaign To Reduce Accidental Falls. The National Safety Council will begin an intensive nation-wide campaign to reduce accidental falls. The campaign will seek to reduce the number of falls in all areas by focusing the attention of management and workers on this type of accident. The Council has singled out falls for special emphasis because of their great incidence in the total accident picture. Most falls can be prevented by voluntary individual behavior. Thus, the campaign not only will seek to enlist management's support in removing unsafe conditions that may cause falls, but also will present safety personnel with an assortment of training aids designed to arouse the worker's enthusiasm for protecting himself. Among the materials will be booklets, films, banners, posters, flip charts, five-minute safety talks, and safety instruction cards. For a sample booklet and a complete list of materials and prices, write the National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.

Submarine Radar "Eyes." The far ranging radar "eyes" of the picket submarine *U.S.S. Salmon*, which was launched at Portsmouth, N. H., are being designed and built by the Raytheon Manufacturing Company, Waltham, Mass. The *Salmon* is a sister ship of the *U.S.S. Sailfish* which was launched in September 1955. Both are radar picket vessels designed specifically to serve as roving outposts, or sentries, to guard against surprise attack by enemy aircraft or ships. The air-search radar to be installed on the *Sailfish* was also developed by Raytheon. The Navy's picket submarines serve as a vital part of the nation's continental defense ring, which includes the DEW line (Distant Early Warning) system in the far North, for which Raytheon also was selected to develop the radars.

New Process for Aluminum. The problem of practical utilization of relatively abundant aluminum for electrical conductors, and connections with existing copper alloy materials has been solved by a new process which provides an integrated surface of pure silver on aluminum bus bars developed by Federal Pacific Electric Company at its Eastern Switchgear Division in Scranton, Pa. The bus is approved by the Underwriters' Laboratories for plug-in electrical connections. The process results in the replacement of surface layer aluminum crystals with those of pure silver. It eliminates bridging of oxide or other surface impurities that frequently occur during electroplating. Uniform coatings of silver are obtained on the walls of drilled holes and adjacent areas where electrical connections are made. The silver surface provides ideal electrical characteristics with self-cleaning properties of the noble metals.

Transistor Plant in Boston. Minneapolis-Honeywell Regulator Company has announced plans for establishing its expanding transistor division in a new location in the Boston area. The division is a major producer of power-type transistors, both for the company's own use and for sales to industry and the armed forces. The new facilities will be leased in Boston to house the division's various activities, including engineering, production, and sales. The transfer to the new location will be made as soon as the facilities are available. The division will establish an applied research section to expand the application of high-power transistors to new markets. The company's basic research work in transistors will continue at the Honeywell research center in suburban Minneapolis, its main plant, where the high-power units now in production were originally developed. The Minneapolis research will be concerned with fundamental studies in the semiconductor field.

California Branch Established. The new branch of Federal Telecommunication Laboratories, of Nutley, N. J., a Division of International Telephone and Telegraph Corporation (IT and T), has been established in the San Fernando Valley district of California. The branch is intended to meet the growing electronic research and development needs of the aircraft and other West Coast industries. The new laboratories occupy the first of a projected series of five structures which will adjoin each other on 13 acres of property just inside the Los Angeles city limits. The buildings will also house the West Coast offices of Federal Telephone and Radio Company of Clifton, N. J., an IT and T manufacturing division.

High-Speed Computer. The IBM *704* is being installed at the Livermore site of the University of California radiation laboratory. The laboratory is operated by the university for the Atomic Energy Commission. Laboratory officials said the machine will add to the installation's capacity to

(Continued on page 18A)

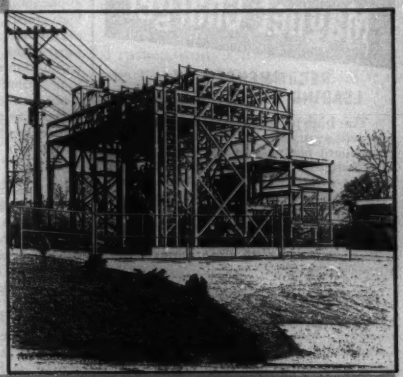
EXTRA HEAVY DUTY—Type "G"

7.8 kv—10,000 amps
15 kv—8,000 amps

Has the same advantages as the Heavy Duty Type "G" plus a more rugged fuse cartridge to withstand repeated high faults. Cutout is equally dependable for interrupting low current faults. Opening action causes the burned link to be "whipped" out... assuring a fast, complete interruption... without having to depend on expulsion force.

CUTOUTS FIELD TESTED...

Here at KEARNEY's Substation Laboratory of 150,000 KVA Transformer Capacity—with a back up power of 445,000 KVA all equipment is tested under rigorous field conditions. KEARNEY Certified Ratings are actual, proved performance ratings... not just theoretical calculations. You can be sure they will do the job they are supposed to do... with a generous margin of safety.



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SAFER MAINTENANCE
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JAMES R. KEARNEY
The Mark of Quality
KEARNEY PRODUCTS

How to Charge
HIGH-FLUX Magnets

Day-long production charging in complete safety and comfort.

Use the
MODEL 942
Magnet Charger

RECOMMENDED BY LEADING MAGNET MAKERS

This high powered condenser discharge unit will saturate large Alnico and ceramic permanent magnets of any shape, using interchangeable, plug-in pulse transformers or wire-wound fixtures. 100,000 ampere-turn output of basic unit can be increased to 200,000 ampere-turns at any time by adding 100 μf condenser banks and appropriate pulse transformer. Adapters for multi-pole rotors, rod, bar, ring and various other shapes are available.

Operates from regular 115 volt, 60-cycle line with only intermittent 10-ampere drain (the few seconds when condensers are charging). Mounted on casters for convenient mobility. Price of basic unit with pulse transformer is less than $2,000.

WE CAN HELP YOU
Our 12 years of magnet charging experience is yours for the asking — send a sample magnet or sketch for free charging analysis.

Write for Technical and Application Data.

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

Industrial Notes

(Continued from page 14A)

make mathematical calculations essential in its program of research on basic science and on classified problems connected with nuclear weapons development. The laboratory already has other machines, including an IBM *701*, for computing work. The new computer is larger and faster than any of the machines now at Livermore. It will make more than 10,000 additions per second, while keeping track of the decimal point, as well as 5,000 multiplications or divisions per second. The new machine will be leased by the laboratory.

Telephone Cable Facilities Expanded. The Anaconda Wire and Cable Company announces that extensive equipment is now being installed for the production of paper insulated, lead covered telephone cable. It is anticipated that these new facilities will be in production during the second half of 1956. These facilities, together with expansion in the plastic telephone cable division, will round out a complete service to users of these types of products. The services of personnel with long experience in the communication field have been obtained for this program. Additions have been made in both staff and field engineering, as well as the research and development departments.

Molybdic Oxide Capacity Doubled. Climax Molybdenum Company's pure molybdic oxide capacity, currently 2.7 million pounds a year, will be doubled by the installation of a second sublimation furnace at its Langeloth, Pa., plant. Reason for the expansion is the increase in demand for applications requiring molybdic oxide of high purity, mainly catalysts and molybdenum metal for powder metallurgy and super-alloys. Molybdenum catalysts are finding increasing acceptance, particularly in petroleum reforming and desulfurization processes, because of their exceptional resistance to poisoning by sulfur and other contaminants, high catalytic activity and economy of use.

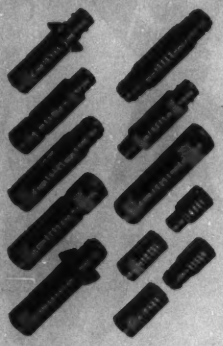
Dark Trace Tube. Increased demand for use of the Skiatron Dark Trace Tube in transmission by closed circuit television of business information and in air traffic control operations has resulted in a contract for production of these unique tubes for the Skiatron Electronics and Television Corporation by National Union Electric Corporation at its Orange, N. J., facility. The Skiatron tube makes it possible for pictorial retention, as long as desired, of such information as bank records, stock exchange data, signatures, and weather maps after they have been transmitted by radar or television signals over regular telephone wires.

Far East Reactor. The first nuclear reactor for the Far East will be built by Atomics International, a Division of North American Aviation, Inc., for the Atomic Energy Research Institute of Japan. A contract between the two organizations calls for

(Continued on page 20A)

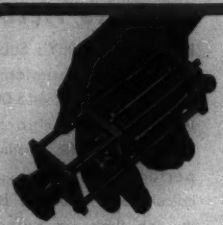
PRECISION ATTENUATION to 3000 mc!

SINGLE *"in-the-line"* ATTENUATOR PADS *and* 50 ohm COAXIAL TERMINATIONS



PROTECTED UNDER STODDART PATENTS

This new group of pads and terminations features the popular Types C and N connectors, and permits any conceivable combination of the two styles.



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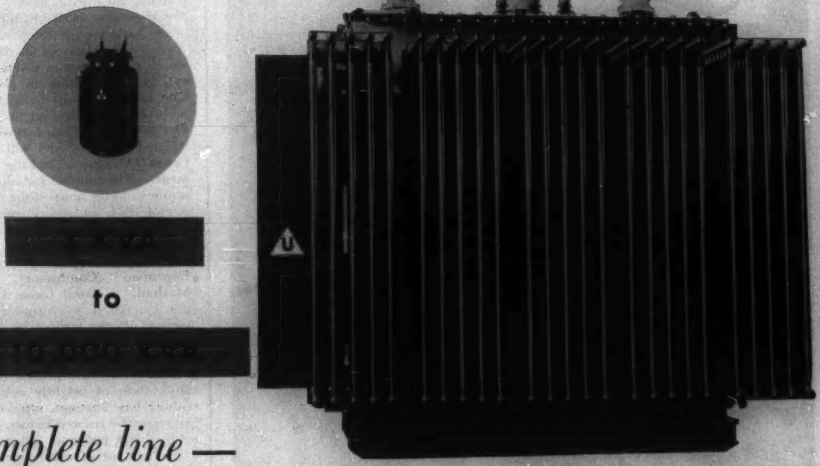
six-position
TURRET ATTENUATOR

- **Frequency Range:** dc to 3000 mc.
- **Characteristic Impedance:** 50 ohms.
- **Available Attenuation:** Any value from 1 db to 60 db.
- **Accuracy:** ±0.5 db.
- **Power Rating:** One watt sine wave power dissipation.

STODDART
Aircraft Radio Co., Inc.
6644-B SANTA MONICA BLVD.
HOLLYWOOD 38, CALIF. • HO 4-9294

Uptegraff LIQUID-FILLED *Transformers*



to

a complete line —

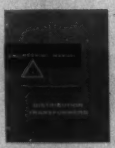
STANDARD and SPECIAL RATINGS

ENGINEERING DATA

Helpful material for planning electrical systems

1. POWER. Bulletin 133 contains dimensions, performance data and other essential information on Uptegraff Power Transformers, 750 to 10,000 KVA.

2. LOAD CENTER. Uptegraff liquid-filled Load Center Transformers in eighteen ratings, from 150 to 2500 KVA, 3-phase are described in Bulletin 132-A.



3. DISTRIBUTION. This bulletin contains detailed specifications of Uptegraff liquid-filled Distribution Transformers, 150 to 500 KVA inc.—ratings, performance data, dimensions, weights and other data. Bulletin 136.

4. OVERHEAD. Characteristics, dimensional details, ratings and other data on Uptegraff type UD Overhead Distribution Transformers are given in Bulletin 135.

When requesting copies of above publications, please write on your company letterhead.

All standard commercial ratings from 3 to 10,000 KVA are available in the complete line of Uptegraff Liquid-Filled Transformers—and special designs are readily available for applications where standard units are not entirely suitable. Prompt deliveries can be arranged, and all Uptegraff Transformers are fully guaranteed. They meet or exceed ASA, NEMA and AIEE standards.

Extensive experience by this firm, which has specialized exclusively in the design and manufacture of transformers, assures the efficiency, dependability and long life of Uptegraff products. The Uptegraff Engineering Data Books illustrated at the left provide a wealth of information useful to executive, engineering and operating departments. We will gladly send copies to anyone interested. Please write on company letterhead.

R. E. UPTEGRAFF MANUFACTURING CO.

Scottdale, Pennsylvania

Industrial Notes

(*Continued from page 18A*)

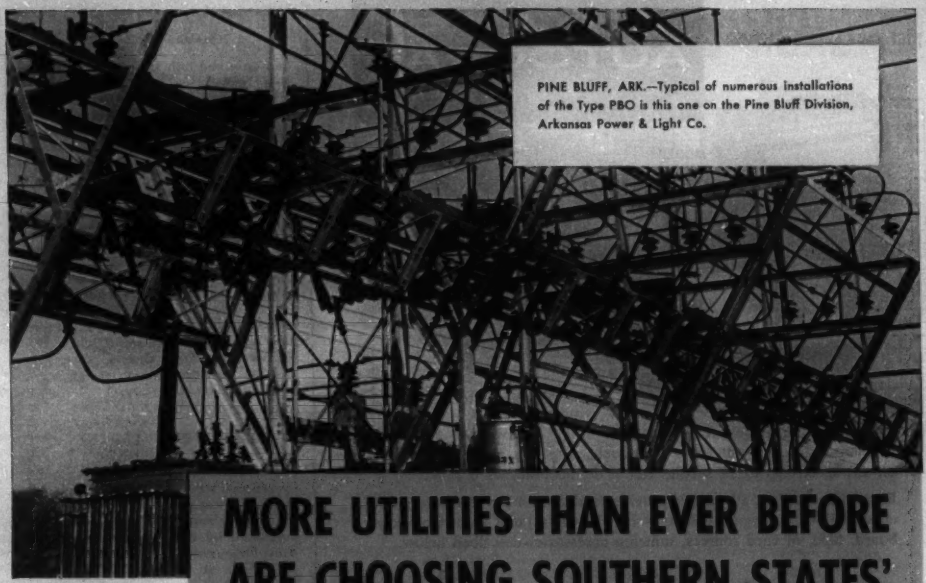
completion within one year of a 50-kw nuclear research reactor to be located near Tokyo. The Atomic Energy Research Institute, a nonprofit foundation sponsored by the Japanese Government and industry will use the reactor for studies in the field of botany, biology, agriculture, materials research, production of radioisotopes, and student training, in addition to general research in the nuclear field. The reactor for Japan will be similar to the industrial research reactor designed and built by Atomics International for the Armour Research Foundation in Chicago, Ill., which will begin operating in about a month. The solution type reactor will be fueled with uranium dissolved in water. About $2^1/_2$ pounds of nuclear fuel will be required. Arrangements for fuel will be made between the Japanese and the U. S. Governments. The contract for sale of the reactor is subject to the terms of the Atomic Energy Act of 1954, and other regulations of the Atomic Energy Commission.

Improved Conductor Identification Method. General Cable Corporation is now prepared to furnish an improved method of color coding the individual rubber insulated, neoprene jacketed conductors of multiple conductor power and control cables. The new process consists of the application of brightly colored synthetic rubber base coatings, supplemented where necessary by colored stripes, to the surface of the black neoprene jacketed conductors. This method of conductor identification complies with Insulated Power Cable Engineers Association Standard *S-19-81*, Method 1 and will result in improved cable quality through the use of black neoprene jackets throughout, brighter more easily recognizable colors, positive conductor identification on immediate inspection, and generally improved cable appearance.

Bare Aluminum for Cables. Bare aluminum has been used for the first time in the United States as aerial power cable sheath-

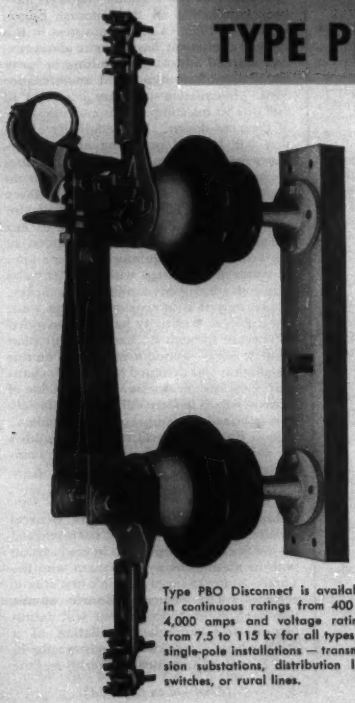
ing in two 6,000-foot transmission lines at North Tonawanda, N. Y. The use of aluminum in place of conventional lead produced a sheathing six times as strong

(*Continued on page 30A*)



PINE BLUFF, ARK.—Typical of numerous installations of the Type PBO is this one on the Pine Bluff Division, Arkansas Power & Light Co.

MORE UTILITIES THAN EVER BEFORE ARE CHOOSING SOUTHERN STATES' TYPE PBO DISCONNECT SWITCHES



Type PBO Disconnect is available in continuous ratings from 400 to 4,000 amps and voltage ratings from 7.5 to 115 kv for all types of single-pole installations — transmission substations, distribution line switches, or rural lines.

The growing popularity of the Type PBO Disconnect, for substation and distribution line switching, can be attributed to the preference of utility engineers for these outstanding features:

HIGH PRESSURE double-line contacts. Positive contact assured by wiping action of accurately machined surfaces. Hard drawn copper bus bar blades; double blade construction. 90° open blade stop unless otherwise specified.

EXTRA LARGE OPERATING RING of heavy duty construction.

POSITIVE LATCHING of blade in the closed position prevents opening under fault currents or from vibration.

BLADE PRY-OUT applies a powerful mechanical force to open the blade even under heavy coatings of ice.

CAST BLADE GUIDES are rigid and wide-flaring to position the contacts properly on each closing operation.

STEEL BASES, hot-dipped galvanized after fabrication, are available to specification.

Full details are contained in our Bulletin 55 PBO, a copy of which will be mailed gladly upon request.

SOUTHERN STATES EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

plot your test data with..

THE MOSELEY AUTOGRAF X-Y RECORDER

Three versatile models feature ranges from 5 millivolts to 500 volts; 200,000 ohms per volt input resistance; zero set and full scale zero off-set; speeds up to ½ second full scale; accuracy of 0.25%.

Rugged and stable, all models provide facilities for curve drawing and curve following. Digital data may be plotted in point form from keyboard, tape, or card sources, utilizing accessories described below.

MODEL 1	MODEL 2	MODEL 3
Drum type	Flat-bed	Desk Type
8½" x 11" paper	11" x 16½" paper	8½" x 11" paper
X-Y Recorder-	X-Y Recorder-	X-Y Recorder-
Curve Follower	Curve Follower-	Curve Follower
	Point Plotter	

MOSELEY ACCESSORY PRODUCTS

MODEL 40 KEYBOARD provides a convenient means for plotting large amounts of tabular data in point-curve form. Self-contained voltage source together with full three column keyboard in both X and Y axes; unit plugs directly into MODEL 2 AUTOGRAF.

MODEL 20 DC VOLTMETER is a servo-actuated, fast, accurate and sensitive instrument. Has large, easy-to-read scale for general laboratory use where ranges from 3 millivolts to 300 volts are desired. For data handling it is furnished with a built-in Coleman digitizer and delivers digital output for operation of printers, typewriters, tape or card punches, etc.

MODEL 30 CARD TRANSLATOR converts information from punched cards into point form for automatic plotting. Handles up to 50 cards per minute, 10 to 200 counts per inch. Plugs directly into MODEL 2 recorder, controls both card reader and recorder for completely automatic operation.

Bulletins describing these instruments are available and we'll be glad to send them to you.

F. L. MOSELEY CO.
409 N. Fair Oaks Ave., Pasadena, Calif.

Industrial Notes

(*Continued from page 20A*)

and only one fifth the weight of lead. A new technique which permitted the aluminum sheathing to be joined with high strength welds without subjecting the cable insulation to elevated temperatures, made the project possible. Niagara Mohawk Power Company, builder of the lines, devised the method from basic welding information supplied by the Aluminum Company of America. The installation also features a new type of extruded cable clamp developed by Alcoa. The new clamps, which can be cut to any length from a special extruded shape, are used for mid-span, turns, and dead-ends. The first U. S. installation of bare aluminum sheathed cable runs from a terminal station to a new transformer substation at North Tonawanda. From there a power system of 4,160 volts distributes to customers in the western section of the city.

Transistorized Power Line Carrier. The first completely transistorized power line carrier assemblies have been placed in full operational service. This protective relaying equipment was designed and built by the Westinghouse Electric Corporation and purchased by the Potomac Edison Company, Hagerstown, Md. Installation of the equipment at each end of the 132-kv Marlowe-Reid line climaxed a series of field tests that Westinghouse engineers have been conducting on the Potomac Edison lines since 1953. Use of transistors in this type of equipment has brought about several marked advantages resulting in lower installation, operation, and maintenance costs. Installation time has been cut in half due to the compactness and simplicity of the new design. The simplicity of design has lowered operating and maintenance costs. Inasmuch as no vacuum tubes are employed, the transistors require no periodic checks. As compared with three months to a year life for the average vacuum tube, transistors can be expected to last indefinitely. The power consumption of the transistorized equipment is very low: 18 watts as contrasted with the 250 watts required by conventional assemblies. Power output is approximately one watt, but sufficient sensitivity has been provided to operate through a channel attenuation of 40 decibels. Previous equipment on this installation was designed for a 33-db channel. Extensive field tests are being made of various other models of these completely transistorized assemblies on the Potomac Edison lines which will include assemblies for voice communications and phase comparison relaying.

Spain's Atomic Reactor. The General Electric Company (GE) has been selected by the Spanish Government in conjunction with its atomic energy agreement with the United States to supply Spain's first atomic reactor. The General Electric atomic power equipment department will manufacture and supervise installation of a standard GE 3,000-kw research reactor in the Moncloa area near Madrid for the

(*Continued on page 36A*)

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Alden Electronic & Impulse Recording Equipment Company
Allied Engineering Division, Allied International Inc.
Amerac, Inc.
American Television & Radio Company
Anton Electronic Laboratories, Inc.
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Arga Div., Beckman Instruments, Inc.
Atomic Instrument Company
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Bart-Messing Corporation
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General Electric has reserved a new high-efficiency germanium rectifier for the chief engineers of the 161 companies listed here. Each firm makes a product which may benefit greatly from new G-E germanium or silicon rectifiers.

Test It Yourself. To prove the superiority of new G-E rectifiers, test the sample unit in your design lab. See the results for yourself. Please send the name of your chief engineer, and mention the product for which your sample rectifier is desired when writing.

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4JA3011 Germanium Rectifier

Medium power, 5-amp rating of 200 volts at 55°C. Extremely low power dissipation and forward voltage drop for excellent efficiency and regulation. Low leakage current meets exacting magnetic amplifier specifications.

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RFL Model 983
OPERATES OVER WIRE CIRCUIT OR MICROWAVE

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2-Way Clear Voice and Reliable Control

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VOICE plus CONTROL
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Provides two, reliable frequency shift control channels at 2800 & 3000 cps isolated from voice by filters. Isolation transformers allow connection to balanced wire circuits. Interchangeable plug-in components and printed circuit boards are used in transmitter, receiver and power supply sections.

The VOICON is one of many RFL terminal units for control, telemetering, teletype, voice or data transmission.

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ALL THESE FEATURES AT LOW COST

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ILSCO CORPORATION

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Industrial Notes

(Continued from page 30A)

Junta de Energia Nuclear (Spanish Nuclear Energy Commission). Negotiations with the Spanish Nuclear Energy Commission are being handled by the International General Electric Company, the GE division in charge of overseas business. The GE equipment will be used for research in the fields of agriculture and medicine, and also will be used to train personnel in the operation of both research and power reactors. Applications will consist principally of studies in nuclear physics and the effects of nuclear radiation on various materials, as well as experiments in bulk shielding. The high-power reactor will be able to support several simultaneous experiments.

NEW PRODUCTS

Modular Cathode-Ray Oscillograph. The experimental unit, identical in performance and operation to Du Mont's newly developed type *350* cathode-ray oscillograph, was demonstrated at the Institute of Radio Engineers Show, Kingsbridge Armory, New York, N. Y. The modular oscillograph is the latest in the long list of innovations by Du Mont during 25 years of pioneering in electronics, including the first commercially practical cathode-ray tube and the first all electronic television receiver. Developed as a mass production technique by the United States Bureau of

Standards, under contract to the United States Navy Bureau of Aeronautics, and by American Car and Foundry Electronics, the modular design uses components printed on ceramic wafers. Each module represents a complete circuit element and is wired into its proper position. The circuits are connected by printed wiring. The combination of modular construction and printed wiring affords complete uniformity of circuitry, rugged construction, and excellent environmental characteristics. Outstanding features of a modular constructed instrument, according to Du Mont engineers, are the simplicity and rapidity of maintenance and repair. Instruments are repaired simply by discarding a faulty module and replacing it with a new one.

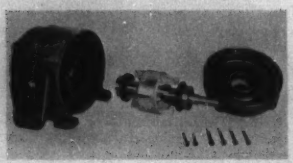
(Continued on page 43A)

New Products

(*Continued from page 36A*)

Long-Life Switching Mechanism. A new and improved switching mechanism which provides longer life has been incorporated into the line of Soreng standard *SNAPAC* switches. Model *750*, panel mounting switch has a liberal overtravel, total travel 1/4 inch to 3/8 inch, and is recommended where the actuating motion cannot accurately be controlled. This model *SNAPAC* switch has high current capacity for direct control of a circuit and is listed by Underwriter's Laboratories for 15 amperes, 125 volts a-c, 10 amperes, 250 volts a-c, 1/2 hp, 125/250 volts a-c rating. Available circuits include SPST normally opened or closed, and SPDT. Its rugged construction makes this switch adaptable for door switch, push button switch or limit, and safety interlocking and control applications. Detailed information can be obtained by writing for bulletin *SL-3*, Soreng Division, Controls Corporation of America, 9555 Soreng Avenue, Schiller Park, Ill.

Synchronous Induction Motor. A basically new synchronous motor, the Synduction motor, for general industrial use, has been announced by Allis-Chalmers Manufacturing Company. Developed at the firm's Norwood Works, the motor is available in ratings from 1/4 to 40 hp, is built on standard induction motor frames and enclosures, and uses a simple die-cast rotor.



The motor requires no brushes, slip rings, or windings on the rotor, separate source of direct current excitation, or special starting equipment as is the case with standard synchronous motors. The new machine offers several advantages over existing types of synchronous reluctance motors, and approaches the efficiency and power factor of squirrel-cage units. The new motor has been designed to operate over a wide frequency, and therefore, a wide speed range. The motors need only standard across-the-line starting equipment, except in the very largest ratings, where reduced voltage starters are required. Prices of Synduction motors are governed by the type and size of standard squirrel-cage frame needed to provide the operating characteristics required, plus a moderate addition to cover the somewhat greater production labor involved. At present, each Synduction motor is being engineered for an individual application. Inquiries must include information on load inertia, accelerating time requirements, electrical supply characteristics, speed range, enclosure required, and any other electrical or

(*Continued on page 44A*)

You can depend on... DALOHM Ω

America's Finest

COLLET-FITTING KNOBS

Dalohm design permits positive locking on all standard shaft diameters full round or flatted with no damaging effect so frequently found when using set-screw type knobs.

FIVE SIZES 5/8"—1 1/16"—1 3/4"—2 1/4"—3"

COLLETS INTERCHANGEABLE. Accommodate all shaft sizes from 1/8" to 3/8"

- Precision cast of thermo setting plastic in easy grip shapes. Match modern styling
- Knobs fit concentrically on shaft and can be positioned accurately and easily on full 360° radius
- Standard pointers and indicators available
- Aluminum dials, three basic types in four sizes; calibrated 0-100 and 100-0 in 180° and 270° rotation. Also plain dials for special applications or markings.
- Highest quality at lowest price

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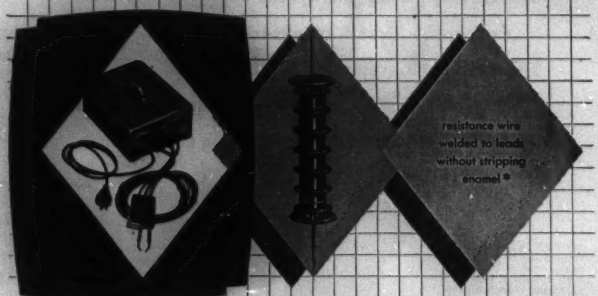
TERMINATE PRECISION RESISTORS WITH SPEED AND RELIABILITY



precision stored-energy welding

WELDMATIC MODEL 1012 TWEEZER TYPE WELDER

welds fine wire to leads or tabs while resistor is on winder. Enamel stripping and flux contamination eliminated, with production time halved. Welded connection is very positive, stable, and rugged.

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Write for Complete Technical Information on Stored Energy Welding

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PROBLEMS TO...

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YOU CAN SAVE many valuable man-hours and production hours by placing your special transformer problems in the capable hands of experienced STANDARD TRANSFORMER engineers. STANDARD engineers can easily detail all of your transformer requirements and oversee their manufacture from beginning to end. There's a STANDARD representative near you. Call him today!

300 KVA indoor unit sub-station or load center, consisting of high voltage, fused air brake switch and low voltage section with circuit breakers and transformer

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REPRESENTATIVES IN PRINCIPAL CITIES

(*Continued from page 43A*)

mechanical information that would affect the design of the motor. For applications where operation of several motors must be synchronized over a range of speed, Norwood Works has also developed an electromechanical drive to supply variable frequency for Synduction motors.

Accessories for Contour Projector. Three new accessories to increase the usefulness of the Kodak Contour Projector, model *8*, have been developed by the Eastman Kodak Company. A special glass measuring stage, for use in vertical projection, permits making linear measurements on the projector over a range of 2 inches by 1 inch. The new stage is available with micrometers calibrated either to 0.001 inch or 0.0001 inch. For measuring angles, the company has developed a rotary screen which replaces the standard ground-glass screen and

is used in either horizontal or vertical projection. A vernier scale permits direct readings to 5 minutes of arc. A third accessory, for use in horizontal projection, is an overlay chart holder, permitting the use of existing plastic or ground-glass charts of varying sizes on the instrument. These new accessories help make the model *8* the most versatile 8-inch screen projector available for optical gauging today. Information on the new Kodak Contour Projector Model *8* accessories may be obtained from the Special Products Sales Division of Eastman Kodak Company, Rochester 4, N. Y., or from the distributor, Optical Gaging Products, Inc., 26 Forbes Street, Rochester 11, N. Y.

Long-Wave Ultraviolet Lamps. New, special-purpose, ultraviolet lamps for better observation of low-grade fluorescence, particularly in the critical areas of pale blue, light green, and red, have been announced by Black Light Corporation of America, San Gabriel, Calif. This long-wave lamp, Blak-Ray model *BLF-6*, utilizes a special tubular filter to cut down on visible light emission from the black light ultraviolet tube; thus less visible light strikes the object being examined. This results in an increase in contrast due to a more

(*Continued on page 46A*)

70% LIGHTER

than comparable rubber-edged metal hangers . . . costs less too

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NYLON CABLE HANGERS

For strong, sure support . . . for sustained periods in temperature extremes from −60°F to 250°F . . . these new, tough, lightweight, molded nylon cable hangers give you all the important features of metal, *plus*.

Even under severe stress, NYLOCLIP's high physical strength holds pre-formed shape indefinitely . . . undamaged by oils, gasoline, alcohol, hydraulic fluids.

Self-insulating nylon is high dielectric non-conductor; eliminates hysteresis losses, grounds, shorts.

Cable insulation fully protected by rounded edges, matte finish inside surface of NYLOCLIP. Stud hole serrations running parallel to cable insure automatic alignment when screw is tightened – prevent cable chafing. Available in 17 standard sizes to accommodate cables or bundles from ⅛" to 2".

Meets MIL-STD-242 and NAVORD OSTD 600-7-3.02.29 (int.)

For proof of performance, send for samples . . . to your specified sizes.

rugged strength of Nyloclip supports this man's full weight . . . 247 lbs.!

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☐ **PLASTICS FOR CORROSION-RESISTANT APPLICATIONS** *by R. B. Seymour and R. H. Steiner.* Shows engineers how to select the right plastic for construction in corrosive atmospheres; the use of plastics as protective coatings, organic linings, chemical resistant mortar cements, casting resins, plastic foams, impregnants, industrial adhesives and reinforced materials. Plastics available for a specific application are compared in tabular form for quick, easy selection of the most suitable material. 1955, $7.50

☐ **COPPER** *edited by Allison Butts.* Treats almost every phase of the chemistry and metallurgy of copper, its alloys and compounds. Full chapters describe copper minerals and ore deposits; smelting, converting and refining; melting and casting; physical and chemical properties; hot and cold working; binary and ternary copper alloys; and uses of the element in chemistry, biology and agronomy. ACS Monograph, 1954, $10.00

☐ **ORGANIC PROTECTIVE COATINGS** *edited by W. von Fischer.* Solutions to the problems of formulation, specification and application. Covers fundamental theory and practice of paint as an engineering material plus anti-corrosive and luminescent pigments, aminoplast resins, hot spray lacquers, emulsion and latex paints, protection of metal surfaces with synthetic resin coatings, new applications of organic coatings in electrical insulation, and the use of silicone resins in heat-resistant paints. 1953, $7.50

☐ **PROTECTIVE COATINGS FOR METALS.** *New 2nd Edition, by R. M. Burns and W. W. Bradley.* Greatly enlarged and almost entirely rewritten, this new edition of Burns' world-famous ACS Monograph contains the latest information on the composition, properties and performance of metallic and organic coatings. Over 60 pages of valuable material concerned with the technology of corrosion control. 1955, $12.00

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☐ **COMPUTERS: Their Operation and Applications** *by Berkeley and Wainwright.* Describes and illustrates the techniques and equipment of automatic computing. Explains in detail machines which have achieved maximum effectiveness, basic concepts which will underlie future developments, and areas where more information is needed. Covers many applications in business and industry. 1956, $8.00

☐ **ELECTROPLATING ENGINEERING HANDBOOK** *edited by A. K. Graham.* Brings you newest information on processing techniques and the engineering factors involved in constructing and installing plating equipment. Covers the design of parts to be plated, specifications, processing sequences, testing, maintenance, waste treatment, and much, much more. 1955, $10.00

☐ **PRACTICAL RADIOGRAPHY FOR INDUSTRY** *by H. H. Cimuser.* Describes basic theory and applications of radiographic techniques to testing both metallic and non-metallic materials. The language of the book is simple and direct. Includes many illustrations of actual radiographs showing defects in metal parts, together with equipment and other essential data. 1952, $6.50

☐ **INDUCTION AND DIELECTRIC HEATING** *by J. W. Cable.* A carefully organized, up-to-date treatment of the uses and applications of high frequency heating. Covers fundamental theory, equipment, coil and electrode design, work handling methods and important applications. 1954, $12.50

☐ **MATERIALS TECHNOLOGY FOR ELECTRON TUBES** *by Walter H. Keal.* Treating such materials as glass, ceramics, mica, tungsten, molybdenum, tantalum, copper, nickel and graphite this book is the first in the English language to offer a thorough scientific description of the components of electron tubes and the methods of uniting them, such as glass-to-metal seals. Each chapter dealing with these materials contains an extensive and, in certain cases, a previously unpublished tabulation of their physical characteristics, their chemical reactions with various reagents, and the processes used in their application. 1951, $12.50

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New Products

(Continued from page 44A)

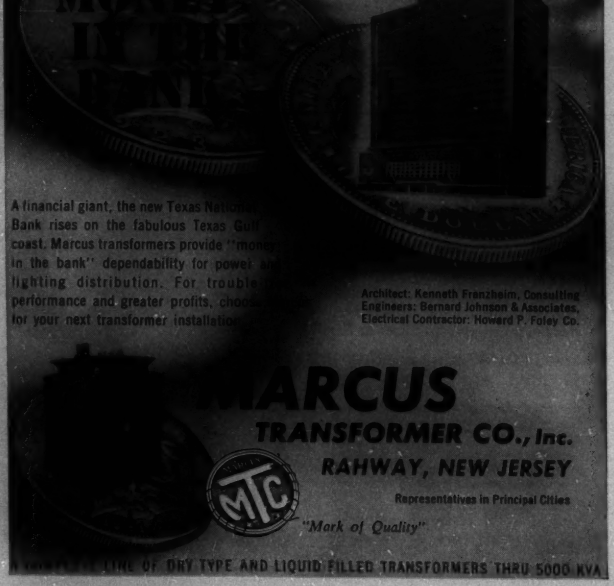
complete drop-out of the nonfluorescent background. With its peak emission at 3,660 angstrom units, the *BLF-6* is especially valuable for sanitation inspection, criminology, chromatography, oil analysis, medical diagnosis, in fact, anywhere that subtle shadings in what otherwise would be termed weak fluorescence areas must be observed. For more information about this special-purpose ultraviolet lamp, write to Black Light Corporation of America, San Gabriel, Calif.

Standard Packaged Power Unit. A completely assembled power indexing unit for straight-line transfer machines or other indexing equipment is now available from Ferguson Machine and Tool Company, St. Louis, Mo. Made entirely of standard components assembled by Ferguson and delivered ready for inclusion in a machine, it saves design and assembly time and manufacturing costs associated with the production of this type of equipment for individual requirements. The unit, known as the Ferguson Trans-Pac, includes gear motor, control shaft drive sprockets, brake actuating cam and microswitch, electric clutch-brake combination and mounting ring, indexing mechanism, and drive shaft coupling. Components, mounted on a steel base plate, are ready for inclusion in a machine and only require necessary connections to control panel and driven parts.

The indexing mechanism, a Ferguson Roller Gear Drive, features modified trapezoid acceleration characteristics (initial force of zero and a gradual increase to maximum acceleration value) to provide smooth vibration-free indexing. For information write to S. K. Georgieff, Engineering and Sales Manager, Ferguson Machine and Tool Company, Roller Gear Division, P. O. Box 5841, St. Louis 21, Mo.

Electronic Amplifiers. Servomechanisms, Inc., Eastern Components Division, announces the release of a line of 400-cycle electronic servo amplifiers. These ruggedized plug-in amplifiers are available for immediate delivery and are designed to drive a wide range of instrument motors in aircraft and missile servo systems. The units are available in 2-, 4-, and 10-watt ranges and are functionally packaged for simple installation and designed to assure long life and reliability with high performance characteristics under extreme environmental conditions. These hermetically sealed amplifiers incorporate the latest miniaturization techniques. Plug-in features incorporated in the design facilitate their application to any control system requiring this function and reduce maintenance problems by permitting simple and quick replacement of the complete unit. Also available as companion equipment is a complete line of 400-cycle power supplies and modulators. All 400-cycle amplifiers are designed to meet applicable United

(Continued on page 50A)


A financial giant, the new Texas
Bank rises on the fabulous Texas
coast. Marcus transformers provide "
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for your next transformer installatio
Architect: Kenneth Franzheim, Consulting
Engineers: Bernard Johnson & Associates,
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MTC
LINE OF DRY TYPE AND LIQUID FILLED TRANSFORMERS THRU 5000 KVA

Grizzly High Voltage Power Cables

Here are 6 samples of widely used competitive neoprene jackets (stretched 200% of original length) at start of test for ozone resistance.

2 hours, 23 minutes after start. Brand "E" is disintegrating. Brand "B" has failed 13 minutes ago; the other brands failed an hour or more before.

Taken 7 hours after start of test—Brand "E" failed after 2 hours, 30 minutes. U. S. Grizzly Power Cable's jacket showed practically no sign of damage. It did not fail until after 18 hours of exposure.

Proved far and away the winner in an Ozone test of 6 leading competitive jackets!

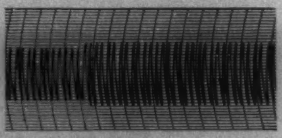
U. S. Grizzly® High Voltage Power Cables are unmatched in performance, durability and all-around economy. Order these superior cables from your "U. S." branch, distributor or write Electrical Wire & Cable Department, United States Rubber Company, Rockefeller Center, New York 20, N. Y.

Obsolete wiring can cause power failure, step up expense and push down your production. That's why it's important to make sure your plant is equipped with Adequate Wiring—adequate not only for today's needs but also for the increased electrical loads needed in your future growth.

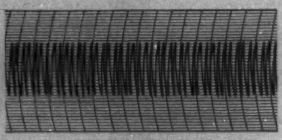
Electrical Wire & Cable Department

United States Rubber

Regulation in *less than* 1/50th cycle . . .



Output of typical electromechanical regulator.



Output of Curtiss-Wright Distortion Eliminating Voltage Regulator from same input. Actual oscillograms of 60 cps voltage.

Actual 60 c.p.s. waveform

PLUS Pure Sine Wave Power

CURTISS-WRIGHT LINE REGULATOR

- **Electronically regulates r.m.s. and peak voltage simultaneously to ±1%.**
- **Reduces typical power line distortion to less than 0.3%.**
- **Furnishes 1.4 KVA of distortion-free power.**
- **Introduces no phase shift between input and output.**
- **Simultaneously provides additional 4 KVA of ±1% electromechanically regulated power.**

Faster recovery time (less than 1/60th cycle, or 330 microseconds) plus the unique ability to *eliminate* line distortion — these are the reasons why the Curtiss-Wright Distortion Eliminating Voltage Regulator has been chosen by more and more laboratories and production test departments. Besides general laboratory use, this line regulator provides simpler, more accurate calibration of meters . . . better design of transformers, synchros, motors . . . easier testing of such components, with fewer rejects . . . easier, more accurate measurement of magnetic properties and receiver sensitivity . . . better a.c. computer performance . . . elimination of fast line transient effects. Write for details.

Electronic Component & Instrument Sales Department

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION • CARLSTADT, N. J.

New Products

(Continued from page 46A)

States Air Force specifications. For additional information, write to W. C. Wilson, Servomechanisms, Inc., Eastern Components Division, 625 Main Street, Westbury, New York.

Static Rejector. Combining impulse-noise rejection with automatic tuning of the receiver to which it is connected, the TRAK static rejector is designed to improve the reliability of code communication by reducing message losses and operator fatigue caused by static noise and receiver drift. The equipment is manufactured by CGS Laboratories, Inc., 391 Ludlow Street, Stamford, Conn. Operating on the principle that a code signal occupies only a narrow frequency band, whereas impulse noise characteristically covers a wide spectrum, the static rejector contains filters which analyze the receiver's audio output at the signal frequency and on each side of it. Noise signals in the sideband regions are instantaneously subtracted from the center channel output, chopping "holes" in the signal when noise occurs and leaving only the code signal to be copied. Additional noise protection is furnished by an adjustable pulse-width discriminator which, when set to the appropriate words-per-minute rate, eliminates all impulses shorter in duration than one "dot." In addition, high-amplitude noise pulses are clipped in special bistable trigger circuits. Models are available for continuous wave transmission and are made to order for frequency-shift communication. A technical leaflet giving circuit information, specifications, and tube complement is available.

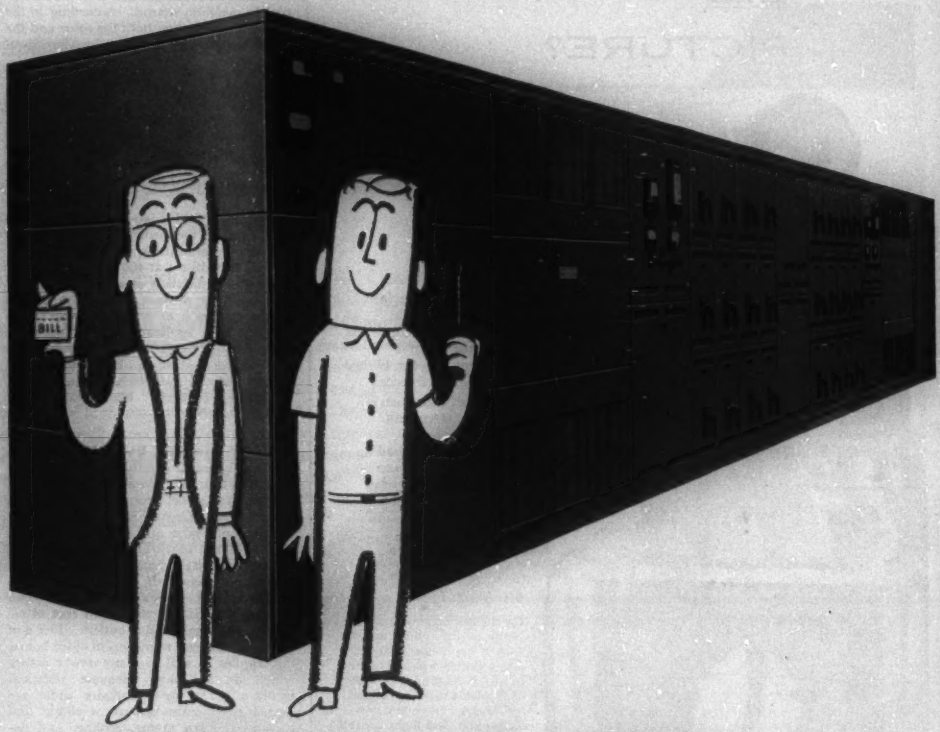
Picture Tube. The 9-inch rectangular picture tube used in the personal television receiver recently announced by General Electric Company, tube department, Schenectady, N. Y. represents a radical departure from standard cathode ray tube design practices. A one-piece funnel and face

plate assembly made with high-speed glass blowing machines similar to those used in manufacturing glass containers will be used. The one-piece funnel and face plate assembly will be purchased from a glass supplier and an electrical grade lead glass neck will be sealed to this assembly at the tube plant. The tube has several other design innovations which could lead to radical changes in methods of making tubes of other sizes.

Resolver for Missile Guidance. A new, size 11, high accuracy induction resolver with a total functional error of 0.01 per cent has been announced by Diehl Manufacturing Company, Somerville, N. J. Designed

(Continued on page 52A)

I-T-E Secondary Unit Substations



. . . designed and built for economy in installation and operation

I-T-E Secondary Unit Substations bring electric power nearer to where you use it—make it more dependable—save you time and money.
They do it in several ways:

- By bringing higher voltages nearer the load and reducing power losses
- By reducing voltage drops inherent in long low-voltage runs and increasing machine efficiency
- By saving space—all necessary components are housed in one functionally designed unit
- By cutting delivery and installation time—units are assembled, tested and shipped ready for immediate installation from one source of supply
- By protecting plant personnel—all live parts are isolated and metal enclosed

I-T-E Secondary Unit Substations can be supplied for any application indoor or outdoor, and in any standard rating. For complete information, contact your nearest I-T-E sales office. Or write I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Phila. 30, Pa.

I-T-E

I-T-E CIRCUIT BREAKER COMPANY • Switchgear Division

Can you see THE BIG PICTURE?

We are looking for engineers who can write—but not men whose interest is limited to details of circuit design and maintenance and operating procedures. We want engineers who can see THE BIG PICTURE.

Our organization is the leader in developing airborne electronic systems. In fact, it has developed the electronic system for every all-weather interceptor in the United States and Canadian Air Forces.

An important part of our work is reporting progress on current projects to our customers.

For this we have established an engineering writing group to write reports, brochures, and films. Engineering writers have the same relative status and salaries as our other engineering specialists.

to qualify

for the engineering writing group an individual must be both a competent engineer and a skilled writer. He must have a good grasp of concepts in the fields of radar, digital and analog computers, communication, and flight control equipment. He must be able to secure the proper information from key engineers in a minimum of time—then quickly put it in concise, lucid, written form. If you think you might be qualified for this work, please send us a resume of your education and experience. It will receive prompt attention.

HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

Scientific Staff Relations

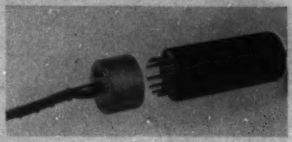
HUGHES AIRCRAFT COMPANY

Culver City, Los Angeles County, California

New Products

(*Continued from page 50A*)

to meet the environmental requirements of the Armed Forces, the new resolver is completely machine wound. According to the manufacturer, when both the rotor and the stator are machine wound the uniformity of



the product yields high performance quality. Further, the resolver has a high input impedance, permitting an excitation voltage of 110 volts a-c at 400 cycles. The new resolver can function at a 70,000-foot altitude without pressurization. To enable design engineers to adapt the size 11 resolver to their applications easily, the component is provided with a pin-type base and mating connector. For further information write or call Diehl Manufacturing Company, Finderne Plant, Somerville, N. J.

Two 7½ Ampere Room Units. Two Yorkaire room air conditioners that require no more electrical current than an ordinary household flatiron are featured by York Corporation. Greatly increased efficiency in the compressor and fan motor permits these 1/2-hp units and "Power Saver" 3/4-hp units to produce ample cooling with little more than half the electricity normally required. The York units usually can be installed without the added cost of rewiring and installation of outlets. This is of particular interest to owners of older homes but applies as well to many newer homes which do not have adequate electrical facilities. The new Yorkaire units are simple to operate because a single dial controls the fan motor, cooling, and dehumidifying. The new "Power-Saver" York room air conditions can be mounted flush with drapes inside the room, or flush with the building outside. The York Corporation of York, Pa., has a complete line of room air conditioners called the Yorkaire Hi-Ef series.

Self-Servicing Television Amplifier. A new type distributed line television amplifier that literally has nine lives and is self-servicing, continuing to give uninterrupted service even after tube failure, has been introduced by the Ampli-Vision Division of International Telemeter Corporation, a subsidiary of Paramount Pictures Corporation. Built in accordance with public utility specifications, found in more costly products, the unique amplifier, known as the Dynam *111*, has been made available for the first time in the low-priced field. A counterpart of Ampli-Vision's famous line of high efficiency distributed line amplifiers, the Dynam *111* was especially designed for use in the rapidly expanding field of master television system installations, including hotels, motels, apartment houses, and other multiple dwellings.

(*Continued on page 56A*)

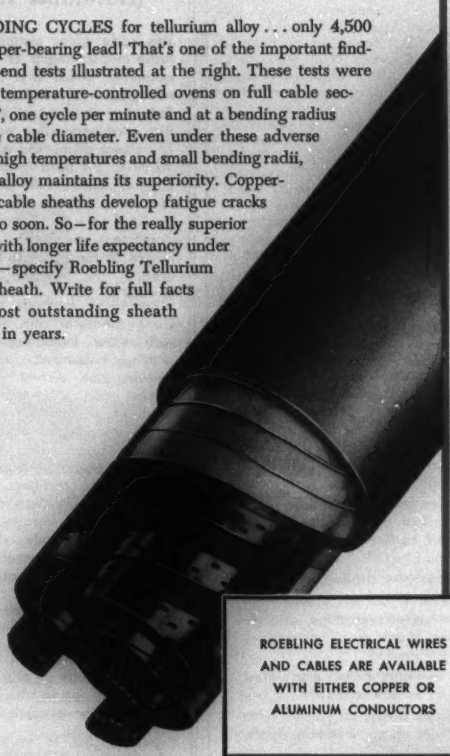
ROEBLING PAPER POWER CABLE WITH TELLURIUM LEAD ALLOY SHEATH

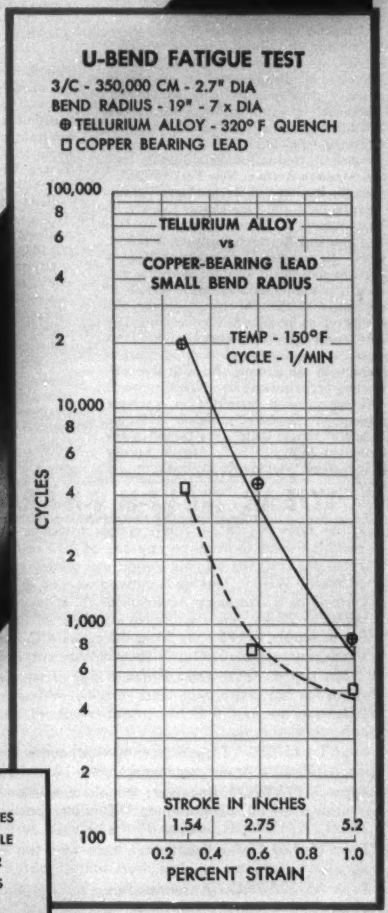
TELLURIUM LEAD ALLOY HAS

4½ TIMES

THE FATIGUE RESISTANCE OF COPPER-BEARING LEAD AT A BENDING STRAIN OF .3%

20,000 BENDING CYCLES for tellurium alloy . . . only 4,500 cycles for copper-bearing lead! That's one of the important findings from U-bend tests illustrated at the right. These tests were conducted in temperature-controlled ovens on full cable sections at 150°F, one cycle per minute and at a bending radius of 7 times the cable diameter. Even under these adverse conditions of high temperatures and small bending radii, the tellurium alloy maintains its superiority. Copper-bearing lead cable sheaths develop fatigue cracks *and fail* far too soon. So—for the really superior cable sheath with longer life expectancy under all conditions—specify Roebling Tellurium Lead Alloy Sheath. Write for full facts about the most outstanding sheath development in years.





ROEBLING ELECTRICAL WIRES AND CABLES ARE AVAILABLE WITH EITHER COPPER OR ALUMINUM CONDUCTORS

ROEBLING

Subsidiary of The Colorado Fuel and Iron Corporation

JOHN A. ROEBLING'S SONS CORPORATION, TRENTON 2, N. J. BRANCHES: ATLANTA, 934 AVON AVE. • BOSTON, 11-15 STILLING ST. • CHICAGO, 5525 W. ROOSEVELT RD. • CINCINNATI, 3253 FREDONIA AVE. • CLEVELAND, 13235 LAKEWOOD HEIGHTS BLVD. • DENVER, 4801 JACKSON ST. • DETROIT, 915 FISHER BLDG. • HOUSTON, 6216 NAVIGATION BLVD. • LOS ANGELES, 5340 E. HARBOR ST. • NEW YORK, 19 RECTOR ST. • ODESSA, TEXAS, 1920 E. 2ND ST. • PHILADELPHIA, 230 VINE ST. • PITTSBURGH, 1733 HENRY W. OLIVER BLDG. • SAN FRANCISCO, 1740 17TH ST. • SEATTLE, 900 1ST AVE. S. • TULSA, 321 N. CHEYENNE ST. • EXPORT SALES OFFICE, 19 RECTOR ST., NEW YORK 6, N. Y.

(*Continued from page 52A*)

TRADE LITERATURE

Industrial Atomic Energy Developments. This release is intended to serve American industry as a guide to Atomic Energy Commission (AEC) developed unclassified information of special industrial interest. You will find listed current AEC unclassified reports on technology. Every effort has been made to limit coverage to reports of AEC developments of direct industrial interest, as distinguished from reports covering developments more scientific or theoretical in nature. All of the reports listed in this release may be inspected at the following AEC industrial information depositories: Atomic Industrial Forum, Inc., 260 Madison Avenue, New York 16, N. Y.; Georgia Institute of Technology Library, Atlanta, Ga.; the John Crerar Library, 86 East Randolph Street, Chicago 1, Ill.; and Stanford Research Institute, Stanford, Calif. In addition to maintaining their reports in convenient form for reference use, these depositories have agreed to furnish all requesters, at nominal charge, photocopies of any report in their AEC collection. The AEC encourages reproduction of AEC unclassified reports, subject to prior arrangement with the authors and with the contracting organizations for which they work. Any organization interested in receiving subsequent releases of "Nuclear Notes for Industry" should write to the Industrial Information Branch, U. S. Atomic Energy Commission, Washington 25, D. C.

Enclosure Folder Available. The publication of a new folder about Shielding's recently developed universal enclosure has been announced. This 4-page folder gives thorough information concerning design features, construction, and applications of this new type enclosure. Handy attenuation chart, detailed illustrations of construction details, and easy to read ordering data are all prominently displayed. To obtain copies of this new folder, write to Shielding, Inc., Box 217, Riverside, N. J.

Distribution Transformer Bulletin. An informative 32-page bulletin providing design and product data on single- and 3-phase distribution transformers, with high-voltage ratings from 480 to 15,000 volts, has been published by the Gardner Transformer Division, Federal Pacific Electric Company. Transformers featured in the bulletin utilize special silicon steel cores. The oriented core material contributes to lightweight designs that require less copper, oil, and smaller tanks; electrical regulation is improved and maintenance is reduced. Use of inhibited oil is described as a safety factor with increased intervals between inspections, and extended transformer life due to ability to handle peak loads. Thirty-eight data tables are given. Three-phase transformer data is supplied in 22 tables. Copies of Bulletin No. *3–500* may be obtained on request to the sales department, Gardner Transformer Division, Federal Pacific Electric Company, Emeryville 8, Calif.

(*Continued on page 70A*)

TYPE AN/TRC-1 F-M V-H-F RADIO EQUIPMENT

The type AN/TRC-1 radio system transmits up to 5 frequency-division-multiplex voice channels on any one of 300 radio channels in the band from 70 to 100 mc. The original design was widely used by the U.S. Signal Corps in World War II, and an improved version is currently in production. This system has a frequency deviation of ± 30 kc. It transmits the band of 300 cycles to 20 kc with a maximum variation of 3db and negligible distortion. Power supply is 115 volts 50 to 60 cycles A.C. The units can be supplied for fixed-plant installation, or in tactical-type carrying cases.

The system has a self-contained 3-kc order-wire channel, and frequency space for four 3400-cycle voice circuits, derived from a separate carrier-telephone terminal. Suitable carrier-telephone and carrier-telegraph terminals are available.

Type T-14J/TRC-1 Transmitter: 40 watts output, crystal-controlled, −12 dbm input, 350 watts power requirement, dims. 10½x12¼x17¼ ins., weight 95 lbs.

Type R-19J/TRC-1 Receiver: Double-conversion superheterodyne, crystal-controlled, +20 dbm output, 100 watts power requirement, dimensions 7¾x12¼x17¼ ins., weight 80 lbs.

Type TS-32D/TRC-1 Oscillator: Three-tube test oscillator giving modulated signal for aligning a receiver, from which it obtains its power supply.

Type AS-20B/TRC-1 Antenna: Three-element dipole array, adjustable over band 70-100 mc. Contained in carrying case with spare elements, tools, coaxial cables, and all accessories. Does not include mast.

Type AM-8C/TRA-1 Amplifier: Power amplifier for use with T-14 Transmitter, 200 watts output. Obtains power from PP-13 Power Supply. Dimensions 11½x12¼x17¼ ins., weight 75 lbs.

PP-13D/TRA-1 Power Supply: Supplies power to one AM-8 Amplifier. Power requirement 800 watts. Weight 194 lbs. Dimensions 12x12¼x34 ins.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY STREET, MONTREAL 3, CANADA
Telephone: UNiversity 6-6887 Cable Address: Radenpro, Montreal
MANUFACTURERS OF CARRIER-TELEGRAPH, CARRIER-TELEPHONE AND BROAD-BAND RADIO SYSTEMS

Master Test Code for

ELECTRICAL MEASUREMENTS in Power Circuits (November 1955)

This code gives instructions for those measurements of electrical quantities which are commonly needed in determining the performance characteristics of electric machinery and equipment. The choice of method and instruments to be used in any given case depends on the purpose of the measurement, the accuracy required, the time and testing equipment available and the nature of the circuit to be measured.

Scope—The methods given include measurements, as made with either indicating or integrating instruments, of power, voltage and current in direct-current and alternating-current single-phase and polyphase rotating machinery, transformers, induction apparatus, arc and resistance heating equipment and mercury arc rectifiers. It also includes measurements made with supplementary instruments and devices. This code does not include such measurements as resistance and temperature which are often included in determining the performance characteristics of electric machinery.

It should be noted that this code does not include all possible tests on electric apparatus or tests conducted for research purposes.

Price: $1.20 to nonmembers; $0.60 to members. Orders should be sent to:

Order Department
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street
New York 18, N. Y.

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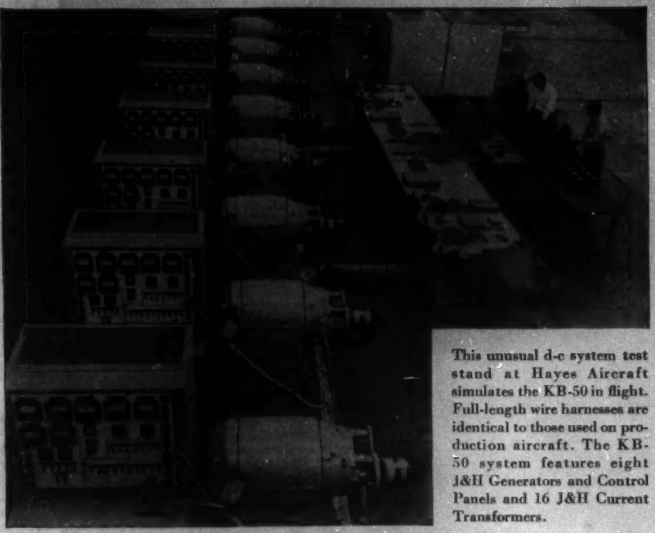

This unusual d-c system test stand at Hayes Aircraft simulates the KB-50 in flight. Full-length wire harnesses are identical to those used on production aircraft. The KB-50 system features eight J&H Generators and Control Panels and 16 J&H Current Transformers.

8 Jack & Heintz Generators paralleled in unique d-c system!

. . . engineers achieve 78% more power for KB-50

The KB-50 will have tremendous refueling capacity. Plans call for fueling of three planes simultaneously.

In converting the Boeing B-50 Superfort into the KB-50 mid-air refueling tanker, a substantial power boost was needed to drive the array of rapid-transfer fuel pumps honeycombed throughout the plane.

The approach lay in developing a new higher rated generator or in paralleling eight available 400-amp machines.

The Jack & Heintz G23 d-c Generator proved to be the answer. Rugged enough to withstand the high vibration characteristics in the KB-50, this generator required only a specially machined housing and a modified mounting flange.

Through the use of the G23, Hayes and Jack & Heintz engineers have achieved a power supply of 3200 amps in the same available space once yielding a maximum of 1800 amps. The unprecedented paralleling of eight generators has been test-proved completely reliable.

Also available is a modified G23 with an increased rating of 450 amps, which is ideally suited to airline applications.

For complete information, write Jack & Heintz, Inc., 17622 Broadway, Cleveland 1, Ohio. Export Dept.: 13 E. 40th St., New York 16, N. Y.

Jack & Heintz G23 Generator

Rating—amp	400
Voltage—d-c	30
Speed Range—thousand rpm	3.8-8
Weight—lb	67
Dimensions—inches	
Over-all Length (from mounting flange)	13 31/32
Over-all Diameter	8
Bolt Circle Diameter	5
Spline, Pitch Diam	.8
Air Inlet Conn., OD	3
Cfm of Air at 6" H_2O & 6000 rpm	165
Rotation as Viewed from end Opposite Flange	CW

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JACK & HEINTZ Rotomotive AIRCRAFT EQUIPMENT

ELECTRONS, INCORPORATED
127 SUSSEX AVENUE
NEWARK 3, N. J.
This modern 18 amp. xenon thyratron is widely used in automatic power control systems. Specifications and application data gladly sent on request.

Trade Literature

(*Continued from page 56A*)

Refrigeration Duty Motors. A bulletin from The Peerless Electric Company describes its line of refrigeration duty motors and gives a complete listing of voltage supply, furnished by major power companies throughout the United States, which show maximum horsepower ratings allowed, starting currents, and special conditions noted by the utility companies themselves. The Peerless Refrigeration Duty Motor has only three parts which wear because of motion or electrical contact; they are the bearings, the contact points on the stationary part of the switch, and the centrifugal parts of the switch. Single phase motors are available from 1 to 3 hp; polyphase from 1 to 5 hp; they are Underwriters' approved. Write for Refrigeration Duty Motor Bulletin, The Peerless Electric Company, West Market Street, Warren, Ohio.

Coil Winding Machine Catalogue. Catalogue No. *56* has 62 pages illustrating and fully describing 42 coil winding machines. Virtually all types of coils may be wound on the various models including deflection yokes, continuous resistance, bobbin, repeater, transformer, solenoid, resistor, lattice-wound universal, space wound, variable pitch, toroidal, armature, and field coils. In addition, 5 new tailstocks, 15 tensions, 3 counters, Model *105* wire scraper, Model *WS-1* wire insulating equipment, 6 wire guides, 3 wire guide assemblies, a pi attachment, wax pot, wire take-off guide, carboloy eyelet, and a variety of gears and cams are pictured with full details given. A page of time saving winding formulas is also included, this catalogue may be had free upon request from George Stevens Manufacturing Company, Inc., Pulaski Road at Peterson, Chicago 30, Ill.

Ceramic Capacitor Catalogue. A comprehensive 20-page catalogue covering all standard or popular ceramic capacitors manufactured by the Cornell-Dubilier (C-D) Electric Corporation has just been released. The illustrated, 3-color catalogue No. *616* consolidates in a clear presentation the extensive variety of C-D ceramic capacitors available to meet any precise applications. These include single and dual capacitance discs, tubulars, printed circuitry and automation discs, high-voltage slug types, and special design types. Catalogue No. *616* supersedes all previous literature on C-D ceramic capacitors. Copies of catalogue No. *616* may be obtained by writing directly to Sales Promotion Department, Cornell-Dubilier Electric Corporation, South Plainfield, N. J., on your company letterhead.

Fluorescent Ballast Bulletin. A 20-page publication on fluorescent ballasts is available from the General Electric (GE) Company, Schenectady, N. Y. The 3-color bulletin, *GEA-6249*, contains descriptive information on the sound rating system,

(*Continued on page 80A*)

ol. 75
1956

Boeing "E.E.'s" help meet two pressing jet-age problems

Boeing electrical engineers play an important part in designing such advanced devices as the prototype sound suppressor (top) and thrust reverser (bottom), shown installed on the Boeing 707. On production 707 jet airliners, however, the two will be combined into a single unit capable of performing the duties of both the suppressor and reverser. Test results have been so satisfactory that Boeing has contracted to deliver 707s to airlines, beginning in late 1958, equipped with sound suppressor-thrust reversers.

Electrical engineers are developing the controls for these devices. They work very closely with other engineers at Boeing in design and research for the 707, the KC-135 tanker-transport, the B-52 jet bomber, the BOMARC IM-99 weapons system, and aircraft of the future. Their work is challenging, creative and increasingly important in electronic development, electrical systems, guidance systems, miniaturization, instrumentation, acoustics, nuclear power, antenna development, and in many other activities.

Boeing now employs more than twice as many engineers as at the peak of World War II. But, because of steady expansion, more topnotch technical men are needed. They will work with superb facilities, including the multi-million-dollar new Boeing Flight Test Center, the latest electronic data reduction equipment, and a new wind tunnel, which will be in operation shortly, capable of velocities up to Mach 4.

Boeing engineers work in closely knit project teams. There are regular merit reviews, individual recognition and ample scope for creative expression. Engineering aides and draftsmen handle routine jobs, freeing engineers for the numerous stimulating assignments.

Life is pleasant for Boeing engineers and their families in the progressive, comfortable-size communities of Wichita and Seattle. How would you like to do interesting and vital work with one of the world's leaders in aviation? Inquire now about an opening on one of Boeing's research, design or production teams.

JOHN C. SANDERS, Staff Engineer — Personnel
Boeing Airplane Co., Dept. E-52, Seattle 14, Wash.

R. J. B. HOFFMAN, Administrative Engineer
Boeing Airplane Co., Dept. E-52, Wichita, Kansas

If you want further information on the advantages of a career with Boeing, please send coupon to either of the above addresses.

Name_____

College(s)_____ Degree(s)____ Year(s)____

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City_____ Zone____ State_____

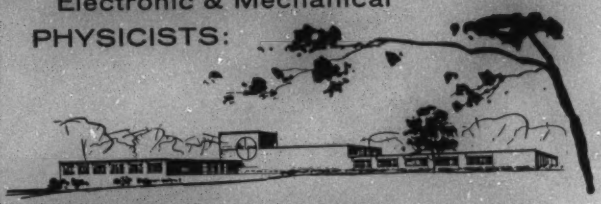
Telephone number_____

BOEING

Aviation leadership since 1916

SEATTLE, WASHINGTON WICHITA, KANSAS

ENGINEERS,
Electronic & Mechanical
PHYSICISTS:



Top Grade Openings

At Melpar *Leader in*

Electronic Research & Development

Due to our continuing expansion program, a number of top grade openings exist in our new laboratories suburban to Washington, D.C. We urge you to consider the following:

1. At Melpar the engineer is not tied to a pre-arranged schedule of advancement. Instead, promotion and advancement are based on *individual recognition*, where skill and ability are the paramount factors of determination.

2. Melpar has doubled in size every 18 months for the past 10 years. New openings occur constantly. This enables the engineer to advance to positions of increased responsibility *as soon as he is ready.*

3. Our unique "project team" basis of organization gives the engineer an opportunity to participate in *entire* problems from conception to completion of prototype, and thus experience the "over-all" approach to engineering problems necessary to eventual directorship responsibility.

4. Our new air-conditioned laboratories encompass over 285,000 square feet and offer *complete* facilities for creative research and design. In addition to our central Model Shop, supplementary facilities, personnel and test equipment are available for *immediate* use within each project group.

5. The Northern Virginia Area, suburban to Washington, D.C., in which Melpar is located, offers excellent living conditions, enjoys the Nation's highest per capita income, fine homes and schools. Recreational, cultural and educational facilities abound. Fully-accredited graduate courses are offered at the Melpar laboratories and at 5 universities in the Area.

Top Grade Openings Exist in These Fields:

Network Theory • Systems Evaluation • Microwave Technique • UHF, VHF, or SHF Receivers • Analog Computers • Magnetic Tape Handling • Digital Computers • Radar and Countermeasures • Packaging of Electronic Equipment • Pulse Circuitry • Microwave Filters • Flight Simulators • Servomechanisms • Subminiaturization • Electro-Mechanical Design • Small Mechanisms • Quality Control and Test Engineering

Write for complete information. Qualified engineers and physicists will be invited to visit Melpar at Company expense.

Write: Technical Personnel Representative

MELPAR *Incorporated*

A Subsidiary of Westinghouse Air Brake Company

3088 Arlington Boulevard, Falls Church, Virginia

Positions also available at our laboratories in: Cambridge, Mass., 99 First St., Watertown, Mass., 11 Galen St.

Trade Literature

(Continued from page 70A)

quality control, life expectancy, design features, development facilities, and customer services.

Lighting Specifications Book. Publication of the new 1956 edition of the RLM Standard Specifications for industrial lighting units has just been announced by the RLM Standards Institute, 326 W. Madison St., Chicago 6, Ill. This edition contains revisions in specifications on both incandescent and fluorescent industrial lighting units, as well as new lighting data of special value to specifiers. According to the announcement, copies of the new book are available without cost or obligation to architects, electrical contractors, lighting specialists, utility lighting men, purchasing agents, industrial executives, and others concerned with the buying, selling, or specifying of industrial lighting units.

Protective Relay Maintenance. A general discussion of protective relay maintenance and testing with particular attention to the equipment and records that are necessary for assuring safely operative relays and breakers has been published by the Multi-Amp Corporation. The folder describes the general types of test equipment commercially available, auxiliary instruments required for trip-time calibration, standard means for conducting these tests, and normal routine to follow. A comparison table lists the characteristic advantages of the various techniques in current application with respect to safety, ease of handling, accuracy, and versatility. Tables and hook-up schematics show how one typical high-current test instrument is used for achieving test results under conditions that closely simulate actual overload values. Copies of "The Why and How of Protective Relay Maintenance" are available without obligation from Multi-Amp Corporation, 10 Third Street, Newark, N. J. Ask for Data Sheet No. *156UB.*

Proper Electrical Tape Booklet. A 12-page booklet to help choose the type of electrical tape best for every insulating and protecting application in electrical construction, maintenance, and manufacturing is offered. The folder, "Tool Up with Tape–Big Four Electrical Tapes," is published by the Dutch Brand Division of Johns-Manville Sales Corporation. It is complete with illustrations, technical data, characteristics, and performance specifications for plastic, friction, rubber, and vinyl color electrical tapes. For free copy write to Johns-Manville Dutch Brand Division, 7800 South Woodlawn Avenue, Chicago 19, Ill.

Control and Transfer Switch Booklet. An informative 26-page booklet on control and transfer switches has been made available by the General Electric (GE) Company. The booklet is profusely illustrated with diagrams and charts. In the

(Continued on page 85A)

(*Continued from page 80A*)

back of the booklet are order forms for the customer's convenience. Free copies are available from the nearest GE Apparatus Sales Office.

Industrial Noise Bulletins. Two illustrated bulletins dealing with current industrial noise problems have been issued. They are Bulletin No. *A-137* which tells how accurate audiograms can be obtained in employee hearing tests in plants and other places of business by providing a favorable environment for audiometric testing through use of a special room, reports the development of a steel room designed and constructed to shield occupants from masking effects of external noise which is demountable and sized to house patient, technician, or observer; and Bulletin *A-140* which relates how latest research developments incorporated in the company's doorless telephone booth excludes outside noise interfering with conversations, as well as furnishing privacy and comfort, in extremely noisy locations in plants, shipyards, mills, utilities, terminals, schools, public buildings, stores, hospitals, and clinics where errors in receiving phone calls can be most serious and costly. The bulletins can be obtained by writing Burgess-Manning Company, Architectural Products Division, 5970 Northwest Highway, Chicago, Ill.

Network Transformer Bulletin. Operating features of Allis-Chalmers oil and *Chlorextol* liquid-filled and sealed dry-type transformers are discussed in a 24-page bulletin, released by the company, which describes the electrical assembly of the units, tap changer and tank design, and the transformers' compact construction, mechanism, and conveniently located accessories. Procedure used in shipping the transformers is also covered. Copies of "Allis-Chalmers Network Transformers," bulletin *61B6152B*, are available on request from Allis-Chalmers Manufacturing Company, 931 S. 70th Street, Milwaukee, Wis.

Metal Fabrication Booklet. A 34-page booklet has been issued by The Risdon Manufacturing Company. Featured are main products, small metal components, and assemblies of parts. Shown in well-illustrated pictures are many typical items as well as the machines that make them. Also described are many case histories in which engineering ingenuity has been able to redesign components previously made in two or three parts by reduction to a complete unit. This booklet will be of particular interest to design engineers. Other products, such as lipstick cases, aerosol valves, special wire forms, and pointed wires as well as safety pins, are briefly touched upon. The booklet is available without charge upon request to Risdon Manufacturing Company, 10 Risdon Street, Naugatuck, Conn.

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—a complete line designed for high range—with stainless steel or beryllium copper construction.

actual size

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Absolute Pressure Potentiometer
This absolute pressure potentiometer measures pressures in ranges of 0-100 to 0-1000 psia—extending the range of Bourns Aneroid Capsule instruments.

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Differential Pressure Potentiometer—*for non-corrosive fluids*
The Bourdon tube in this high range instrument is made of berryllium copper for use with non-corrosive fluids. With the low pressure port vented to the atmosphere, this unit can be used as a gage pressure instrument.

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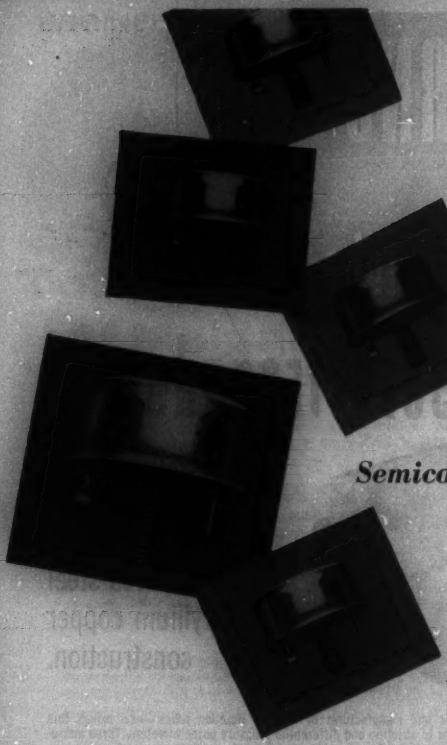

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